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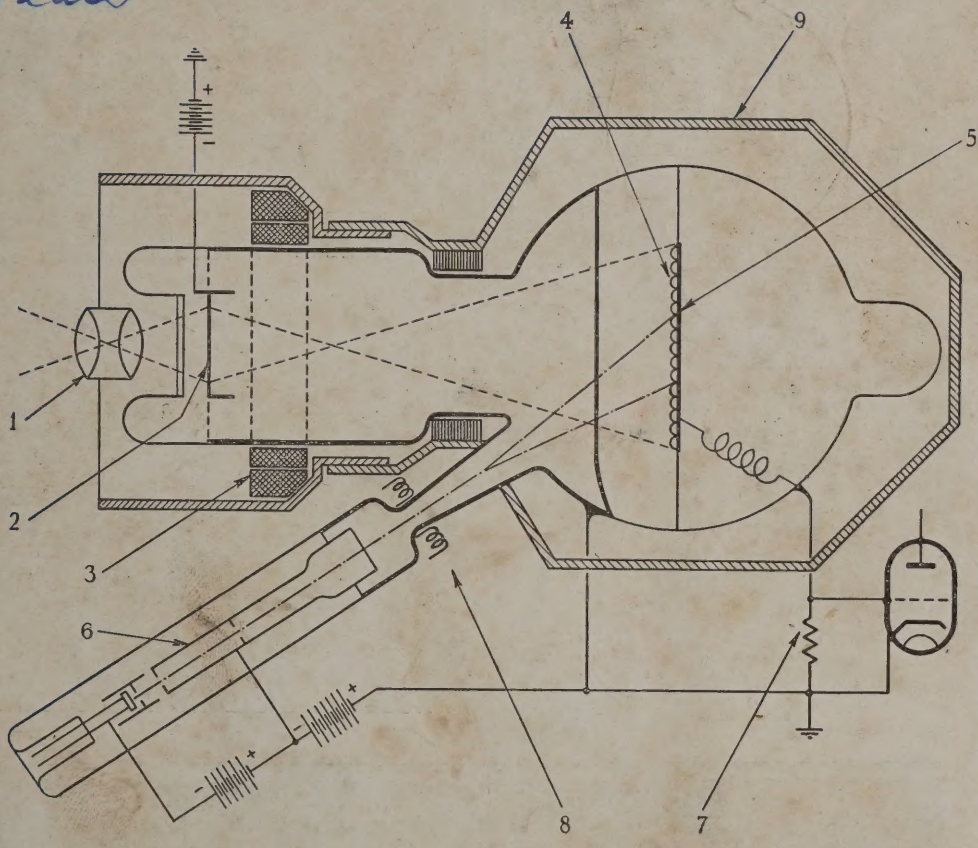

In this issue:

The "R. & E." T.V. Synch. Signal Generator

A Medium Powered P.A. Amplifier

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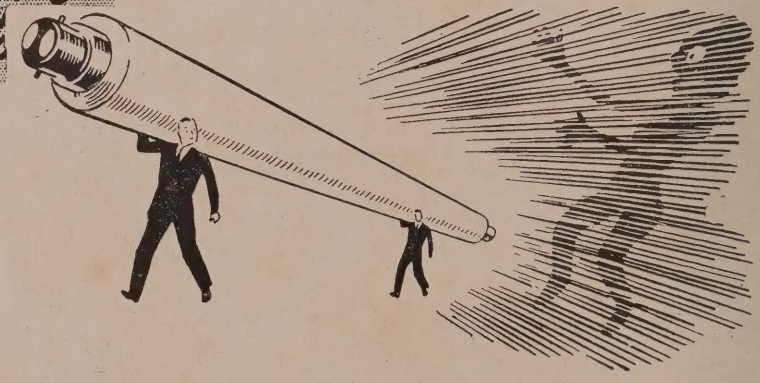

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Radio and Electronics

OUR COVER this month illustrates the interior construction of the Super-Emitron, a television camera tube which has been used by the B.B.C. for outside broadcast work. It is printed here to typify thep resent issue of "Radio and Electronics" as the first to contain technical material about TV—or at least about one important aspect of it. We expect that from now on, a proportion of space in this journal should be devoted to TV articles every month, enabling our readers to commence "reading up" this subject with an eye to developments in the not-too-distant future.

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Technical Education- Is it Worth It?

It is remarkable the difference a distance of 12,000 miles can make to our lives and livelihoods. Both here and in the United Kingdom are to be found well-established radio industries. It is natural that ours should not only be very much smaller, but should also be rather different in character from its British counterpart, but it is a little surprising to find that the two are divergent in one aspect to which size and general character should make little difference. It is the extent to which each employs engineering and science graduates to which we refer. There is at the present time in England a grave shortage of engineers and physicists in the electronic industry, but here we doubt whether an engineering graduate would be able to find a job in a New Zealand manufacturing firm. It is true that a great deal of developmental research goes on in England that has little or no chance of being done by commercial firms here. Such things as the development of the electronic ancillary equipment needed for use with new weapons of war, are to a large extent handed over to the great electrical firms, with extensive laboratory facilities, to carry out, and these defence programmes require large staffs of trained engineers and physicists. But this cannot account for the whole difference.

A look through the staff lists of our radio factories and large firms would reveal very few men concerned with the design and production engineering departments who have qualified as bachelors of engineering (advancing in electronics) or of science, with radio-physics as a subject. Why is this? Partly, we think, it is because of the kind of work that the firms referred to are doing, and partly because of what seems to be a fairly deep-rooted conviction among employers that university-trained men are of no use to them. "Of what use to us," they say, "is a man who comes from the university, full of the best theoretical knowledge, no doubt, but completely unversed in the ways of commerce." Sometimes, their plaint goes somewhat as follows: "It takes practical common sense, not loads of mathematical theory, to build radio sets, and these chaps with their degrees haven't got any practical background at all.'

The trouble is that these views are the embodiment of what may yet turn out to be very dangerous half-truths. It is the half-element of truth they contain which makes them dangerous, and it is easy to see how it is that events seem to bear out the contention that degreed men are not necessary in our radio industry. The industry is still young enough to depend on technical men who have grown up with it, and whose great store of knowledge is built on a lifetime of experience, rather than on any formal engineering training. In fact, at the time when these men became engaged in an industry then in extreme infancy, there was no method by which they could have obtained a formal training. But the fact that these men, who may have no formal qualifications at all are carrying on successfully, having advanced with the times, does not mean that when they disappear from the scene, their jobs can be filled by men who, like them, have no formal qualifications. In the industry's own interests, it should set about employing some of the young engineering and science graduates who are interested primarily in electronic work, with the idea that these will be their technical executives of the future. Of the not-too-distant future, too, it may well turn out, because it cannot be long before TV is with us, and, without any disrespect, some of the "old-timers" may not feel like coping with something which is so far removed technically from what they have been doing for so long, and some of them may not be able to. Even if we put it down as debatable whether new blood, of the kind under discussion, is essential at the present time, there is no room for doubt that it will be needed when television comes.

From time to time we read plaintive letters in the daily press bemoaning the "export of New Zealand brains" to the old country, and it is regrettably true that the radio industry is doing little or nothing to prevent those samples which could be of most use to it from exporting themselves. Another somewhat unworthy facet of the thing is that while university graduates have a right to expect a recompense by way of salary that in some way reflects the time and money they have put into becoming qualified as they are, those who should employ them seem to boggle at the cost. Instead of complaining that these men expect a high salary, and yet have no commercial experience, it would be much better for everyone if the employers set about giving them some. It stands to reason that once an engineer has learned something of the economics of the type of engineering in which he is engaged, he will be able to turn out design and production work that will repay the employer many times over for the man's salary. And when it comes to assimilating new techniques, like television, and translating them into practice, the trained engineer will be virtually the only man who can cope satisfactorily. Given time, perhaps, plenty of untrained men would be able to learn enough to do the same job, but it is in the saving of this valuable time that the trained man will show to advantage. Meanwhile, we are in danger of letting all those graduates who should be in our own industry, go 12,000 miles away and cash in on the serious shortage of engineers and physicists in Britain.

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A Simple Circuit for a High-Powered Amplifier

Since most of the amplifiers that have appeared in these pages have been designed for use as gramophone amplifiers, few of them have exceeded 10 watts in power output. For use in the home, this amount of power output is ample, but there are many purposes for which a greater power is needed. Public address, for example, and the modulators of radio transmitters. It is with these applications in view that we present the circuits to be found in this article. As well as a very straightforward power amplifier circuit, this article describes a pre-amplifying and mixing circuit which is notable for its freedom from hum—that bug-bear of high-gain amplifiers.

INTRODUCTION

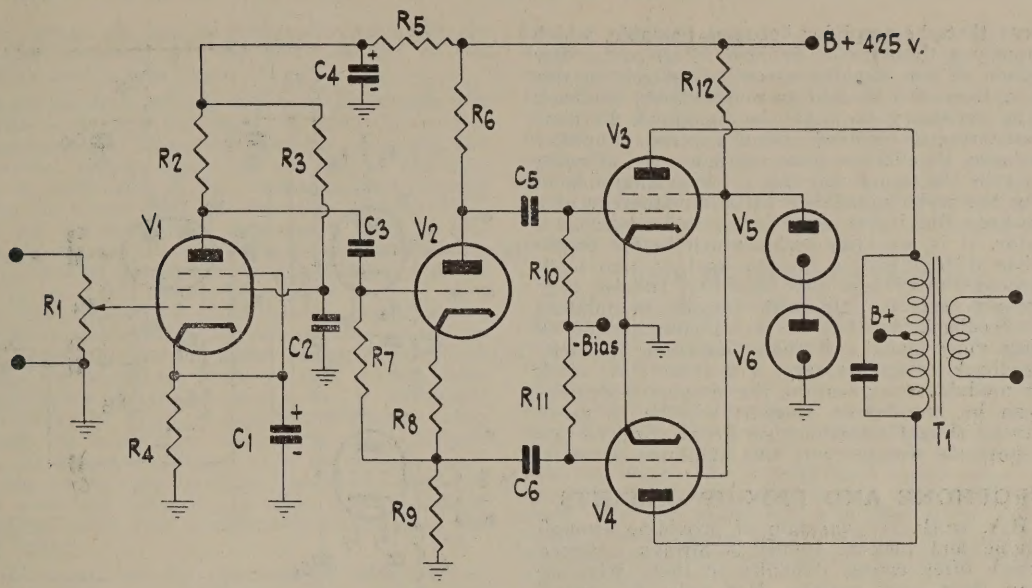
Those who have had some experience of small or medium-powered audio amplifiers are sometimes at rather a loss when it comes to providing thirty or forty watts of audio power. The reason is usually to be found in the fact that for powers up to ten or fifteen watts, and especially for high-fidelity applications, Class A amplifiers are the rule rather than the exception. For powers above 20 watts, pure Class A amplifiers become rather too costly for many purposes, since they are the least efficient type known. This means that a Class A amplifier provides its power output for a greater expenditure in plate voltage and current than any other type. Since power transformers and smoothing chokes rapidly become more expensive the larger they are, continuing to use Class A amplifiers for powers over 20 watts costs real money, and unless the highest possible quality is essential, the extra expenditure cannot be justified on the basis of the results obtained.

When, a good many years ago now, this fact first became apparent, about the only real competitor to the Class A amplifier was the Class B one. For very high power outputs, Class B amplifiers are still in common use, but valves and circuitry have developed to such an extent that Class B amplifiers do not really come into their own until rather more than 100 watts are needed. The difficulty with them is that they are very difficult to design—almost impossible for the amateur—and even if one can design a Class B amplifier, the specification would certainly call for non-standard components, such as the driver transformer and the swinging choke needed to give the power supply good enough regulation.

For the power outputs of which we are talking in this article, namely from 20 to 50 watts, Class AB operation is much more suitable. The plate current swing of a Class AB amplifier is usually much less than that of a Class B one, and this makes the design of the power supply much simpler. In addition, if the output tubes are operated in Class AB_1, there will be no grid current. This is perhaps the greatest advantage of Class AB_1 push-pull operation of output valves. If the right valves are chosen, the efficiency will be appreciably higher than for Class A, and yet no input transformer is needed, because as long as there is no grid current, the driving voltage can be supplied by a resistance-coupled driver stage. This again is a considerable advantage, for as long as the published conditions for the output valves are adhered to, as recommended by the makers, no difficulty need be experienced in designing the rest of the circuit. The 87 is the logical choice for an amplifier of from 30 to 40 watts, since a pair can easily give this output in Class AB_1.

CIRCUIT OF THE MAIN AMPLIFIER

The main amplifier is very simple as far as circuitry is concerned, but has two somewhat unusual features. One is the use of fixed bias, and the other, the regulation of the screen-grid voltage by means of two voltage-regulator tubes. This latter feature is of considerable importance, and illustrates a point which is often given insufficient attention, namely the regulation of the power supply. In this sense, the word connotes the drop in voltage of the power supply resulting from the increase of plate and screen current which occurs at full output. It is usually expressed as a percentage, being the percentage change in power supply voltage when the current drawn from it changes from minimum to maximum. One good feature of Class A amplifiers is that the regulation of the power supply is unimportant, because this kind of amplifier draws the same plate current whether unloaded or fully loaded. However, if a Class AB amplifier with a rather large plate current swing is operated from a power supply of poor regulation, it will be found that the power output is not as great as the valve data indicates it should be. The effect is greater with tetrodes than with triodes, because the screen voltage has a greater effect on the characteristics of the tube than does the plate voltage. Because of this fact, it is more important for the regulation of the screen voltage to be good than that of the plate voltage supply. One method of coping with the difficulty is to use a small, separate power supply for the screens, so that, although their current swings appreciably too, the swing is much smaller than is the case with the plate voltage. However, this is an expensive solution, especially as precautions must then be taken to see that the screen voltage cannot be turned on unless plate voltage is applied too. This protection can take the form of a time-delayed switch, set in action by the turning on of the plate voltage. Some valves have so large a screen current swing that voltage regulator tubes are unable to cope with it, but that of a pair of 807s is small enough to come within the regulating range of these tubes. The suggested conditions for the circuit described are those in which the screen is fixed at 300 volts, while according to the power output required, the plate voltage and the plate load impedance can be varied. With a plate voltage of 400, the rated power output is 32 watts, but with 600 volts, the maximum power output is 54 watts. The use of the regulator tubes dispenses with the additional power supply, and are even better from the standpoint of regulation, since they will keep the screen voltage constant to within a volt or two. This is rather better than can be expected from a separate power supply.



In order to make the most of the plate supply available, fixed bias is recommended for the 807s. This can be provided by a battery, or from a separate rectifier, operating from one side of the main power transformer. Since there is no grid current, the regulation of the grid bias source is not at all important, but it should not insert too much resistance into the circuit, since with fixed bias, there is a maximum grid circuit resistance rating that should on no account be overlooked. In the case of 807s, it is 100k. per valve, and the grid leaks have accordingly been made this value. Rather larger coupling condensers have to be used with these resistors in order to preserve the low-frequency response than are usually found, and if for any purpose it is desired to limit the low-frequency response, as, for instance, when the amplifier feeds horn-loaded speakers exclusively, this can easily be arranged for by reducing the size of these condensers to the more usual 0.1 μf. or 0.05 μf. While on this point, it may be worth-while to mention that it is possible to damage horn-loaded speakers by providing them with high power input at frequencies below the lowest for which they are designed. This is because at low frequencies the horn does not load the diaphragm, which then has little to prevent it from moving much farther than its maker ever intended, and becoming permanently deformed, or even torn. Since bursts of low-frequency energy can easily find their way into the amplifier via the microphones, should one be accidentally knocked, or through some such cause, it is good practice to limit the response of the amplifier. The speaker cannot reproduce the very low-frequency portion of the spectrum in any case, nor is it desirable for crisp intelligible speech, so that the low-cut is desirable from several points of view.

The phase inverter is our old friend the "concertina" circuit, with slightly unusual values. The plate and cathode load resistors have been made somewhat lower than usual, because of the low values of the following grid leaks. Doing this improves the phase splitter circuit's characteristics without doing anything but reduce the maximum undistorted output voltage. There is still plenty, however, with which to drive the output valves, and more than there would be if the more usual 100k. resistors were used in the plate and cathode circuits.

COMPONENT LIST

V_1, 6J7.
V_2, 6J5.
V_3, V_4, 807.
V_5, V_6, VR150.
R_1, 500k. pot.
R_2, 250k.
R_3, 1.5 meg.
R_4, 1200 ohms.
R_5, R_6, R_9, 25k.
R_7, 500k.
R_8, 1500 ohms.
R_{10}, R_{11}, 100k.
R_{12}, 3k. 10-watt w.-w.
C_1, 25 μf. 25v. electro.
C_2, C_5, C_6, 0.25 μf.
C_3, 0.05 μf.
C_4, 16 μf.
C_7 (not marked), 0.002 μf.

NO NEGATIVE FEEDBACK!

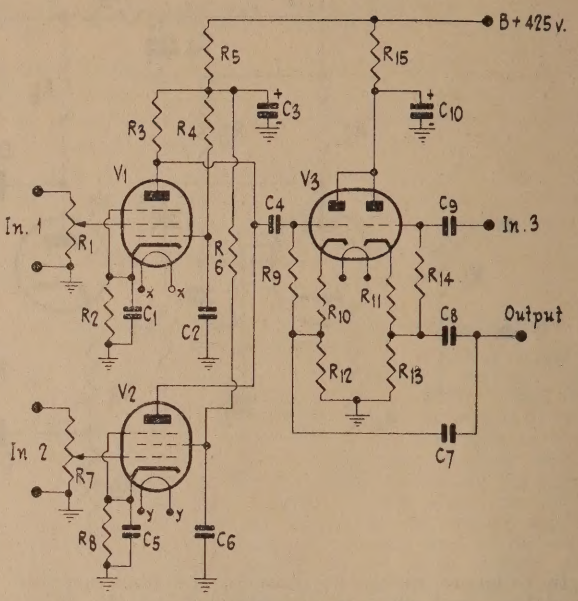
It may surprise some to see that negative feedback has not been used in this amplifier. It would not surprise us to hear someone say that ANY amplifier can be improved by the use of negative feedback. Unfortunately we do not agree. It all depends on what an amplifier is to be used for, and what sort of distortion specification it is to meet whether feedback is justified or not. In practically all cases it is, but this is one where it is not. Rather can it lead to all sorts of trouble if the amplifier is to be used for public address work. The difficulty is one which, we are afraid, has often been overlooked by those who have built P.A. amplifiers for their own use. All may be well in cases where there is no great length of speaker cable attached to the output transformer. Similarly, when long high-capacity leads are used in a fixed installation, it may often be possible to compensate for them, and satisfactorily design a feedback circuit AFTER the amplifier has been installed. But when the amplifier is to be used with varying numbers of speakers, and with unknown lengths of line, so that it is impossible to say how much capacity will be shunted across what secondary windings, feedback can be dangerous. The capacity referred to can alter the feedback conditions to such

an extent that the amplifier becomes unstable, which is obviously a thing to be avoided at all costs. For this reason, it was decided to omit feedback on this amplifier. Even if it is used as a modulator, feedback is not as necessary as might be imagined. Perhaps the main virtue of feedback round a tetrode amplifier is in reducing its effective plate resistance, and allowing it to act in the same way as a triode amplifier in damping the wide impedance variation inherent in a loudspeaker. But if the amplifier is to be used as a modulator, it is working under much better conditions than it does with a speaker load, so that feedback becomes much less of a necessity. Indeed, very good results can be had with tetrode modulators without feedback, so that the extra complication of providing more gain, and then "knocking it back" with feedback is unnecessary. For both P.A. work and for modulator application, the simpler the equipment can be, the better, since it will be so much easier to fix should something go wrong. And no-one will dispute the simplicity of this amplifier circuit.

MICROPHONE AND PICK-UP CIRCUITS

For P.A. work, the question of providing enough microphone and pick-up inputs is always a vexed one, which often causes difficulty to those who are designing their own circuits. Not only do several inputs have to be provided, but these usually require different gains, to suit the pick-up or microphone being used. The arrangement illustrated here is capable of any amount of modification without difficulty. It should be regarded as illustrative only, for any one arrangement can obviously suit only a limited number of people as it stands. The circuit given provides for two high-gain microphone inputs and one pick-up, without special compensation, but it will be shown how compensation for the different types of record can be added, with only one extra valve.

Perhaps the one thing which causes most trouble in high-gain pre-amplifier stages is hum; hum which arises from the heater circuit of the pre-amplifier, and not from the H.T. supply, which these days can very easily be so well filtered that hum in it is entirely negligible. One often sees it stated that the easiest way to eliminate hum in such circumstances is to use D.C. for the heater supply of the pre-amplifier valves, but very few amplifiers seem to employ it. Needless to say, it is not the easiest thing in the world to use a rectifier and smoothing system to obtain a pure D.C. supply giving, say, 6.3 volts at 0.3 amps., or some such figure. The rectification part can easily be accomplished by means of a metal rectifier, which in these days is a relatively inexpensive device, but it is the smoothing which causes most of the difficulty. True, to be much better than raw A.C., the smoothing can be relatively poor, but it does not seem good practice to use a D.C. supply that is not very pure, when the object is to eliminate hum at the source. However, when we have a medium-powered amplifier such as the one this article describes, there is an alternative method of heating the pre-amplifier valve or valves which has received very little attention from the designers of amplifiers. It is to use the very well-filtered H.T. supply. At first sight, this might seem difficult, if not impossible, since most of the valves likely to be used take 300 ma. through their filaments, and it would certainly not be possible to draw as much current as this from the H.T. supply in addition to the requirements of the output valves, unless a prohibitively large supply were built. In addition to this,



COMPONENT LIST

V_1, V_2, 12J7.
V_3, 6SN7.
R_1, R_7, 0.5 meg. pot.
R_2, R_8, R_9, R_{14}, 250k.
R_3, 125k.
R_4, R_6, 1.5 meg.
R_5, R_{12}, R_{13}, 50k.
R_{10}, R_{11}, 1500 ohms.
R_{15}, 25k.
C_1, C_5, 25μf. 25v. electro.
C_2, C_6, 0.25 μf.
C_3, C_{10}, 16 μf. 450v. electro.
C_4, C_7, C_8, C_9, 0.05 μf.

there would be a tremendous waste of power, since the pre-amplifier valves' heaters would need only 12.6 volts, while the remaining voltage would have to be dropped through a resistor.

The difficulty can be overcome, however, in the following way. For the pre-amplifier valves, we use 12-volt valves, whose current requirement is only 150 ma. The two heaters are wired in series, so that a supply of 25.2 volts at 150 ma. is needed. Now if we look at the H.T. currents drawn by the output valves at no load and at full load, we find that with 400v. on the plates and 300v. on the screens, the no-load currents are:

Plate current	102 ma.
Screen current	6 ma.

This makes a total of 108 ma. which is not quite enough. Now we also have current flowing through the VR tubes in the screen circuit, and with the values shown, the VR tubes draw 27 ma., so that the total H.T. current, not counting the 6J7 and the 6J5, which take only very few milliamps, is 135 ma. Thus, if we pass the H.T. current through the heaters of the pre-amplifier tubes, we will have almost the right current for them. The question is, how can this be done? Remembering the old scheme called back-bias, this is easy. The centre-tap of the power transformer is not connected to ground, and the negative terminals of the smoothing condensers are taken to the centre-tap instead of to ground. Then, one end of the series pair of filaments is grounded, and the other is returned to the insulated H.T. terminal. In this way, the heaters of the pre-

amplifier valves are used in exacty the same way as a back-bias resistor, and the H.T. current of the amplifier is used to heat them.

With a total drain of only 135 ma., the current will be slightly less than the rated 150 ma., but this is quite unimportant. When the amplifier is in use, the plate current swings from 102 ma. up to 152 ma., making an additional 50 ma. But the power output fluctuates in actual use, so that the average H.T. current will be somewhere between a total of 135, with no signal, and 185 with full output continuously. These conditions are perfectly satisfactory for the heaters of the 12J7 pre-amplifier tubes, and we have as pure D.C. flowing in their heater circuit as we have in the plate circuit of the power tubes. It is thus virtually impossible for the heater circuit to introduce hum into the amplifier. Tests of this scheme have been undertaken in our laboratory, and it was found to work perfectly. With no special precautions taken other than the method of feeding the pre-amplifiers' heaters, the output was found to be particularly hum-free, to the extent that the slight hiss due to amplified thermal noise and noise in the plate resistors of the pre-amplifier tubes was considerably louder than the residual hum.

The full output of the pre-amplifier is applied to one grid of the cathode-follower mixer circuit, and individual volume controls are placed at the grids of the pre-amplifier valves. This enables the gain control at the input of the main amplifier to be used as a master gain control, and those at the grids of the pre-amplifiers to be used as individual controls for the separate channels. In theory, it is best to place the individual gain control following the pre-amplifiers, but in this case, noise and hum were so low in level that it was not found necessary to do so. If it is desired to apply the full input voltage from the microphone to the pre-amplifier, it will be necessary to put the channel gain control after the pre-amplifier. With the circuit shown, of course, it is not possible to put the gain controls anywhere else, without also foregoing the mixing function. If only two microphone inputs, and no pick-up input are needed, then each pre-amplifier tube could be given its own plate load resistor, and could feed into the grids of the cathode-follower mixing circuit.

THE METHOD OF MIXING

In this circuit, two methods of mixing signals are illustrated. The first is obtained simply by using a common plate load resistor for the two pre-amplifier tubes. This has only a very slight effect on the gain of the valves, so slight as to be unnoticeable, but it does affect their maximum undistorted output voltage. However, as low-level amplifiers, this does not matter at all, since their output will be only a few volts at most. The arrangement would only reduce the output voltage available in a case where something like the maximum was needed in order to excite the following stage fully. As it is, the 6J7 in the main amplifier needs only a fraction of a volt for full output.

The second method of mixing is to take two cathode followers and simply connect their outputs in parallel. This scheme has much to recommend it. It produces no gain, and from this point of view it is ideally suited to the problem of feeding the pick-up to the main amplifier without introducing additional gain that is not needed. For example, a crystal pick-

(Concluded on Page 48.)

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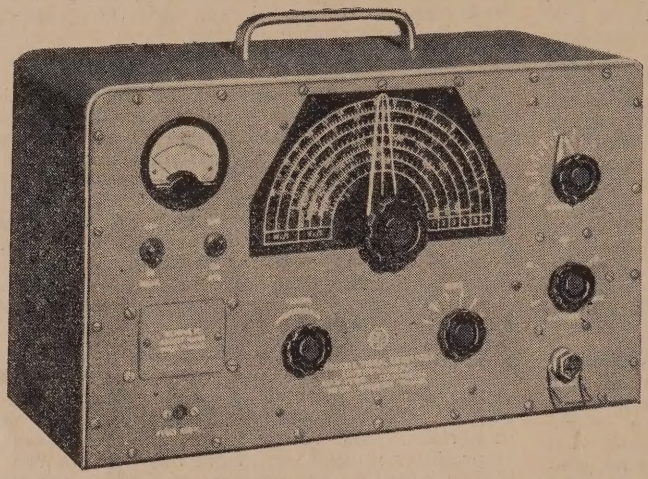

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A Wide-Band Electronic Switch

In the Easter 1949 issue of Radio and Electronics *was published a circuit of an electronic switch for showing two waveforms simultaneously on the same cathode ray tube. This circuit was very successful, but has one drawback. The frequency response was not wide enough to enable such things as short pulses, and high-frequency square-waves to be displayed without distortion of their shape. This new circuit employs wide-band technique to extend the high-frequency response of the switched amplifiers, so that pulses and other non-sinusoidal waveforms can be handled without distortion of their true wave-shape. In particular, it will be found useful by those who decide to follow in a practical way, the series of articles, commencing in this issue, describing the "R. and E." TV Synch. Signal Generator.*

INTRODUCTION

There are a number of reasons for wanting to show two pictures at the same time on an oscilloscope. One is when it is necessary to compare the shape of one wave with that of another. For example, the waveform of an audio oscillator can be compared with that from an amplifier using the oscillator as a signal source, in order to estimate the degree of distortion introduced by the amplifier. The main usefulness of a 'scope which will show two waveforms at the same time, however, is in demonstrating, or in finding out the *timing* of one waveform with a specified portion of another used as a reference point. For example, suppose for some reason a short pulse is to be generated, and must occur at a specified time, such as the moment when a certain sine-wave crosses the zero line. Unless both waves can be shown simultaneously on the oscilloscope there is no easy method of telling what the time relationship is between the two. Or again, it may only be a simple case of adjusting a phase-shifting circuit so that two sine-waves are so many degrees different in phase. In any such case, looking at one of the waveforms of interest on its own does not tell us anything at all about the problem. But if both are displayed at once, on the one time-base, then the times of any happenings on one of them can be accurately related to some happening on the other. The two waves can be superimposed on the face of the C.R.T., and it is a very simple matter to see directly the parts of the two waveforms which coincide in time.

Unfortunately, most of the waveforms with which this facility is needed are not simple sine-waves, but are more often rectangular pulses, or square-waves, saw-tooth waves, or other shapes, in which there are fast movements of the C.R.T. spot. Such fast waveforms unfortunately need wide bandwidths in any amplifiers that are to handle them, for if an attempt is made to look at them on the 'scope, with an amplifier whose response covers only the audio range, one is usually doomed to disappointment. Those nice sharp corners, and fast transitions which look so well when the wave form is applied directly to the Y-plate of the 'scope come out quite rounded, and with quite noticeable slopes, that one instantly recognizes as distortions of the truth. The trouble is, that the eye, in looking at such things, is a much more discriminating organ than the ear. Suppose, for example, that one is working with a circuit whose job it is to produce a train of narrow pulses. If the pulses are small in amplitude, they may need amplification in order to show them at a reasonable size on the C.R.T. But if the amplifier used has not a wide enough frequency response, the picture actually obtained on the screen will not be a true representation of what is happening in the circuit where the pulses are being generated. Such an amplifier is therefore useless as a means of examining the real shape of the pulses. A good rule of thumb for finding the high-frequency response needed for square-waves and pulses is as follows. With pulses, a bandwidth in megacycles equal to the reciprocal of the pulse duration in microseconds, is needed. That is to say, to view properly a pulse lasting 1 μsec., an amplifier is needed

FIG. 1

whose response extends out to 1 mc/sec. If the pulse lasts for 10 μsec., an amplifier with a response out to 1/10 mc/sec., or 100 kc/sec., will do. These figures, however, should be regarded as a minimum acceptable bandwidth, and it should be realized that any bandwidth over and above these figures will result in a truer representation of the shape of the pulse. With saw-tooth voltages and square-waves, with which the question of pulse-length hardly arises, another rule-of-thumb will give a minimum figure for the required bandwidth. It is to make the bandwidth of the amplifier such that all harmonics of the fundamental frequency, up to and including the tenth, are passed. Thus, with a saw-tooth at 10,000 c/sec., the amplifier should respond at least as far as 100 kc/sec., and preferably further, if the picture obtained is to be a reasonably true representation.

But what has all this to do with the electronic switch? Plenty; the reason is that such a switch must contain an amplifier stage, so that all the foregoing remarks apply with all their force to the amplifiers that may be included in the circuit. The electronic switch circuit referred to above used amplifiers with conventional audio circuit values, so that it was really only suitable for audio frequencies, or at best for non-sinusoidal waveforms with fundamental frequencies not higher than 2000 or 3000 c/sec. In television and radar work, and in other special equipment, such as pulse communication gear, waveforms at much higher frequencies must be handled, so that the original electronic switch was not really suitable, although it would undoubtedly still act as a switch. When it was decided to build in our own laboratory some television synchronizing circuits, it was realized that a new electronic switch was almost essential. This is the reason for the new design described in this article. Fig. 1 (a) shows how a series of pulses, which really do have square corners, should look on the oscilloscope, while Fig. 1 (b) illustrates what the same pulses can easily become if they are passed through an amplifier with insufficient high-frequency response.

It can be imagined how useless a picture like Fig. 1 (b) is when one is attempting to determine the exact timing of, say, the leading edge of the pulse!

CIRCUIT DETAILS

The switch consists of two amplifier valves which act quite independently, except that their plates are tied together, and use a common plate load resistor. The two waveforms to be examined are fed one to each valve, so that if it were not for the switching action, the circuit would simply add together the two waveforms. However, in order to prevent this, the amplifiers are controlled by a square switching wave, which is applied to their suppressors. This wave is generated by a multivibrator, which uses two more pentodes. The multivibrator runs at approximately 50 c/sec., and the exact frequency is not at all important. The waveforms in Fig. 3 show, more clearly than a great many words can do, just how the switching takes place. Each amplifier valve is controlled from one plate of the multivibrator, in such a way that when the suppressors are driven negative, the plate current is cut off, and the amplification is zero. On the positive half of the switching waveform, the suppressor is made very slightly positive, and the normal amplification of the valve takes place. But as the two valves are fed from opposite sides of the multivibrator, they are switched on and off alternately, so that while one is amplifying the other is cut off. The result of this action is that for a hundredth part of a second, one of the input waves is delivered to the output, but not the other. During the next hundredth of a second, the situation is reversed, so that the two signals are alternately allowed to appear at the output terminal. It still remains to show how both the waves appear on the screen of the C.R.T. at once, but this is not a difficult task.

Suppose the waveforms being examined have a frequency of, say, 2000 c/sec., and that in order to show four cycles of the waveforms on the screen, the time-base has been adjusted to run at 500 c/sec.

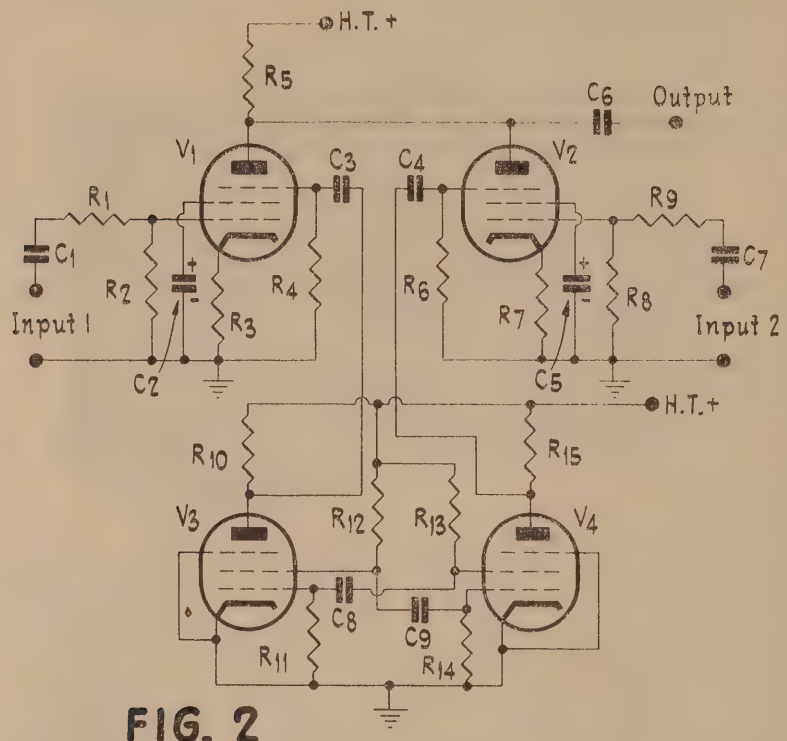

FIG. 2

COMPONENT LIST

C_1, C_7, 0.25 μf.
C_2, C_5, 8 μf. 500v. electro.
C_3, C_4, 0.25 μf.
C_6, 0.25 μf.
C_8, C_9, 0.002 μf.
R_1, R_9, 1 meg.
R_2, R_8, 50k. (or to suit signal voltage).
R_3, R_7, 300 ohms.
R_4, R_6, 10 meg.
R_5, 5k.
R_{10}, R_{15}, 50k.
R_{11}, R_{14}, 1 meg.
R_{12}, R_{13}, 50k.
V_1, V_2, V_3, V_4, 6AU6.

This is done just as if the electronic switch were not present, by applying some of the waveform to be examined to the synch. terminal of the 'scope. Now let us see what happens. For 1/100 sec., waveform A is applied to the Y plates of the C.R.T. from the switch output, and during this time five horizontal sweeps of the time-base will occur, displaying waveform A in the usual manner. Then the switching action occurs, instantaneously, so that waveform B is applied to the Y plates, and A is cut off. For the next 1/100 sec. five more sweeps of the time-base occur, displaying waveform B. Now the switching action, which causes the pictures of A and B to alternate at a rate of 50 times a second, is too fast for the eye to follow, just as is the time-base repetition rate. Accordingly, the pictures of A and B appear superimposed on the screen, just as if they were occurring simultaneously, whereas in fact they are rapidly following each other. If the time-base is slowed down to 50 c/sec., or slower, the picture on the screen will be quite different, and will naturally then show the sequence of events taking place. Indeed, the last waveform in Fig. 3 will appear, proving our contention that the switch works in the way described!

Although the illustration above has assumed that the time-base frequency is an exact multiple of the

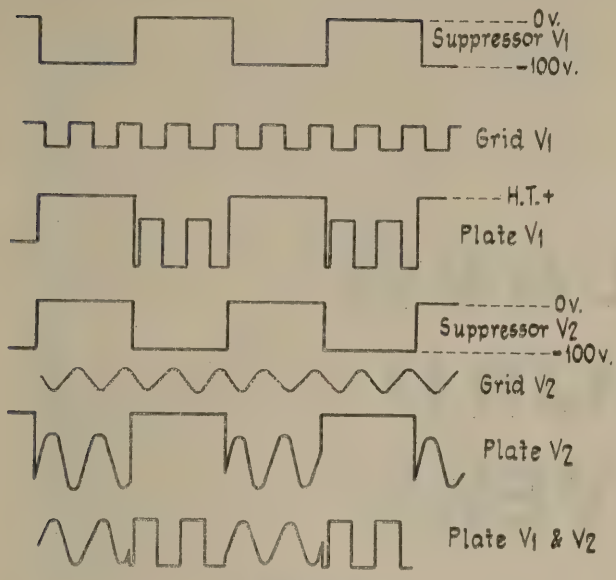

FIG. 3

switching frequency, this does not have to be so. Indeed, there need not be any particular relationship between the two, and if there is not, it will have no effect at all on the picture. The only requirement is that the waveforms to be examined must not last longer than one half the switching period. That is to say, the slowest rate at which the time-base can be run, and still produce the correct "simultaneous" picture, is twice the switching frequency. This is fairly obvious if one stops for a moment to think about it. Each amplifier is on for only 1/100 sec., if the switching frequency is 50 c/sec., so that if the time-base is running at a lower rate than 100 c/sec. one trace will not be completed before the switching action takes place again. Therefore, the whole of waveform A is not completed before waveform B begins to be shown.

SOME OF THE SNAGS

So far we have said nothing about the actual design of the circuit. This is not essential, for the would-be builder, but some of the circuit values are a trifle unusual, and so should really be explained. This paragraph will also show why these unusual values should not be altered, and what will happen if an attempt to do so is made.

First of all, there is the use of extra-large coupling condensers between the multivibrator plates and the suppressors of the switched amplifiers, and the use of electrolytic condensers as screen bypasses. Both these features arise from the same, or rather from similar reasons. It is a difficult matter to pass any square-wave through an amplifier valve without some sort of distortion taking place. We have already dealt with the rounding off of the sharp corners which occurs when the high-frequency response is insufficient. The defect which becomes apparent when the low-frequency response is inadequate is also important in the electronic switch circuit, as can be

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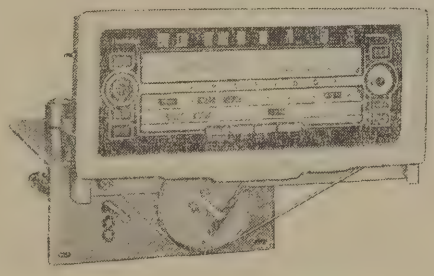

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seen from a glance at Fig. 4. Here is illustrated what happens to a wave with perfectly flat "tops" and "bottoms." These, instead of remaining flat, become curved. How, then, can this affect the switch circuit? If we look for a moment at Fig. 3, we will see that the outputs of the amplifier tubes contain two components. One is the waveform to be examined, and the other is a square-wave at the switching frequency.

FIG. 4

Now, if the amplifier cannot handle the switching square-wave properly, the distortion of Fig. 4 takes place, and the output of one valve looks like Fig. 5. Because of this, when the time-base is run at a high rate, in order to display the waveforms of interest, the two traces have a thickness equal to the amount of droop occurring in the switching waveform as passed by the amplifier circuit. This, naturally enough, completely spoils the picture, just as if it were impossible to focus the spot of the C.R.T. sharply.

Up till now, we have not said anything about the square-wave appearing at the plates of the amplifier tubes, except that it is clearly shown in the diagrams of Fig. 3. Since the amplifier valves, and their circuits, are supposed to be identical, the square-waves at the plates of each will be equal in amplitude. And since they are in opposite polarity (the suppressors are fed with out-of-phase square-waves from the multivibrator) the two which appear across the common load resistor will cancel out. If they do not, there will still be some slight amount of square-wave present in the output, and this will lead to a separation of the two traces on the C.R.T. This can clearly be seen if the switch is in operation, but no input waveforms are applied to the grids of the amplifiers. In general, then, the amplifiers both have to handle square-waves at the switching frequency and do it properly in order to prevent nasty thick traces from making their appearance. The low-frequency response of the amplifiers must therefore extend well down if the fault is to be avoided. It is not good enough if the amplifiers are flat down to the switching frequency. The response should be flat down to at least a tenth of this if excessive droop is to be avoided. This, then, is the reason for the large coupling condensers, and the very large screen bypass condensers. It is also the reason for omitting cathode bypass condensers altogether, for if any attempt is made to use them, it is found that complete bypassing cannot be obtained, and the droop is worse again.

The reason for the variable control in the screen circuit will also be apparent. It is to take care of small differences in amplification in the two valves, and to enable the square-waves in their plate circuits to be exactly balanced out. When the switch is operating, but without input voltages to the amplifier tubes, the potentiometer is adjusted until the two traces coincide exactly. If desired, the control can also be used to produce a slight shift between the two pictures. This is helpful when the switch is in use, as it enables the portions of the picture that belong to the two different waveforms to be readily distinguished. In many cases, this is not easy to do, unless one picture can be moved slightly. In the circuit previously described, in which ordinary audio amplifier valves and circuit values were used, the balancing control was also recommended as a shift control, for shifting the two pictures right away from each other. In this circuit, however, it cannot be used in this way. The reason is that the square-wave output is quite small, even for maximum unbalance of the control, and if steps are taken to ensure a large shift, then the gain of the amplifier valves changes quite drastically at the same time. This is inconvenient, and is largely avoided in the present circuit by not allowing the unbalance to become very great.

USING THE 'SCOPE AMPLIFIERS

When the electronic switch is in use, it is often best to feed the output straight to the Y-plate of the C.R.T. without going through the Y amplifier. This is because the 'scope amplifier is not usually good enough either at high or low frequencies, unless it is a special wide-band one. If the trace-broadening effect shows us, when the the 'scope's amplifier is used, it is clear evidence of insufficient low-frequency response, and the only thing for it is to leave the amplifier out of it. If the amplifier has inadequate high-frequency response, then the effects on the examined waveform will be exactly as described earlier. However, it may be desirable to modify the scope's amplifier for better low-frequency response,

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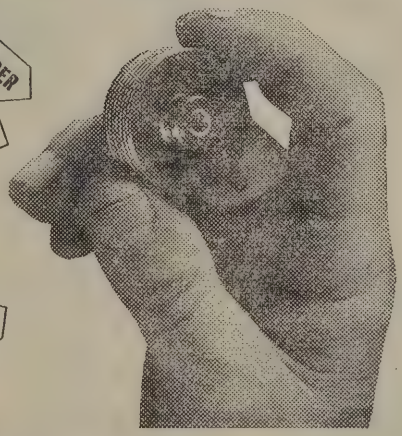
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if it is already wide enough on the high side, because with the low load resistor that has to be used in the switch's amplifier stages, the maximum undistorted output voltage is not very great. A 'scope amplifier which can be used will ensure that a full-sized picture is obtained on the screen.

NO D.C. RESTORER DIODES

In the previous switch circuit, D.C. restorer diodes were used at the suppressors of the amplifier valves. Their purpose was to ensure that the suppressors could not be driven positive by the switching waveform. This time, the effect of the suppressor waveform was investigated more closely, and it was found that the suppressors drew current on the positive half-cycles of the switching wave, and thus acted as their own D.C. restorers, making a separate diode unnecessary. The diodes were therefore omitted as serving no useful purpose.

GAIN OR ATTENUATION?

One of the unfortunate things about an electronic switch such as this one, is that it provides amplification, whether it is wanted or not. Frequently, amplification is not needed at all, in fact the signal voltages are so large that attenuation is required instead. This being the case, it is necessary to place an attenuator at the input to the amplifiers. These have a gain of approximately eight times, and a maximum output voltage, before distortion sets in, of 7.6 volts. Therefore, the maximum signal that can be fed to the grid of the amplifier tubes is almost 1 volt peak. With this knowledge, it is possible to work out how much

(Continued on Page 48.)

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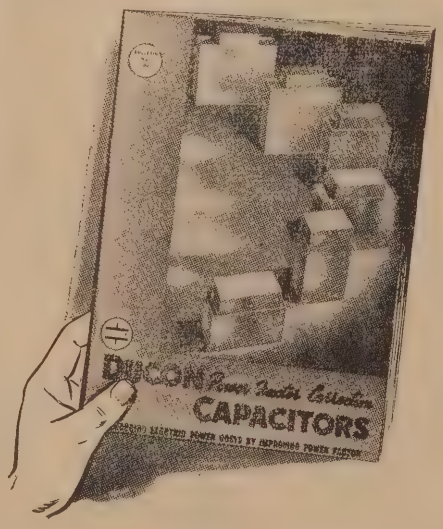

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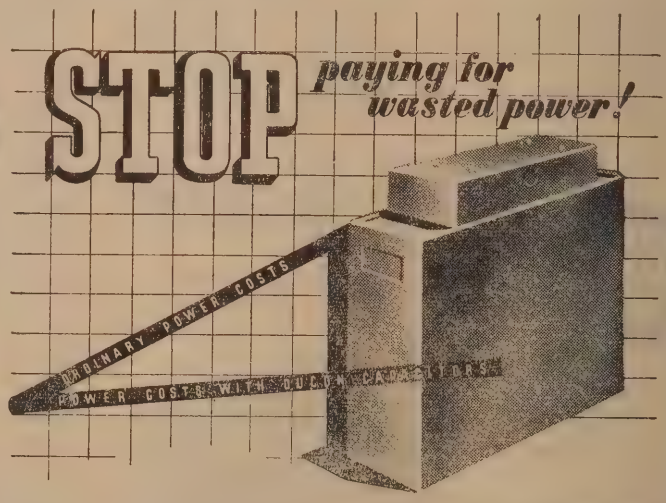

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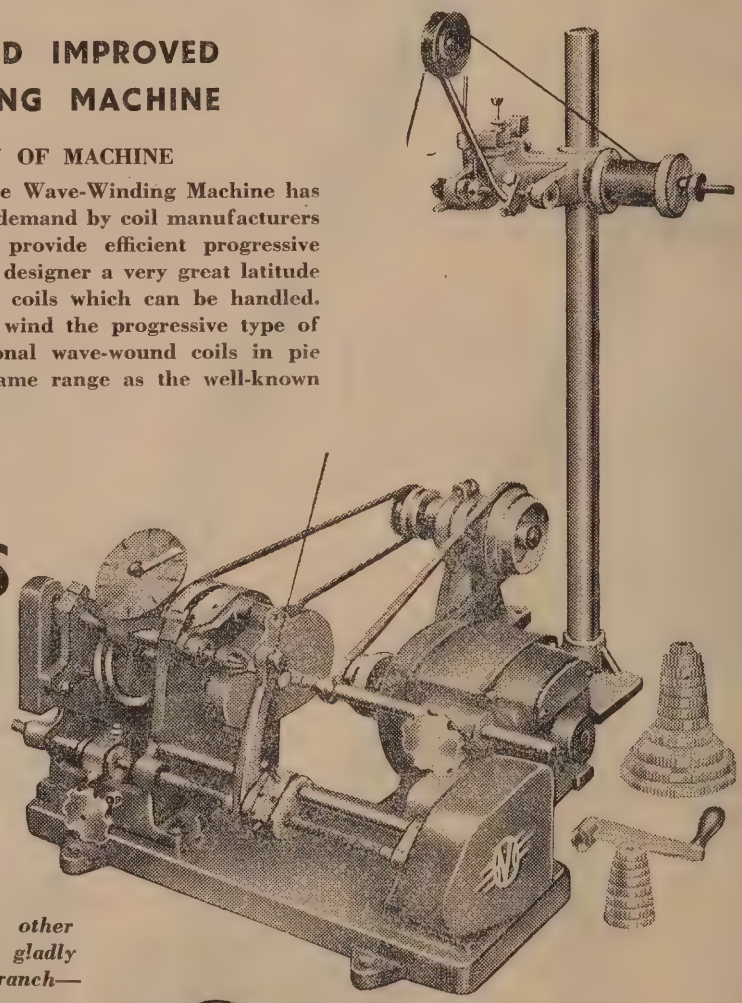

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The "R. & E." Synch. Signal Generator

By W. D. FOSTER

This is the first of a series of articles describing in detail the circuits and construction of a generator which will produce the standard synchronizing signal for the B.B.C.'s 405-line television picture. The design of the circuits is part of our own programme for familiarizing ourselves with the techniques peculiar to television, and it was thought that many of our readers would be interested in reading about the project, even if they had no intention of building anything similar. At the same time, a generator such as this is an essential piece of equipment for many of those who will become practically concerned with TV as soon as the Government has made its long-awaited policy statement on the future of television in New Zealand.

INTRODUCTION

In introducing the technical aspects of television into these pages for the first time, it is felt that the approach to be used is rather an unusual one, but one which will probably be found more useful and instructive by readers than the time-honoured one of presenting a series of articles describing the elementary principles of the subject. It is not, after all, as though we were living in a technical vacuum, for a very good cross-section of the overseas periodical literature devoted to our subject is readily available to us. Many readers of *Radio and Electronics* would be sure to say to themselves, "Just another 'Elementary Course in Television'," and turn the page. The truth is that almost every periodical has at one time or another featured such a series of articles; in addition, there are numerous excellent text-books covering the subject from almost every conceivable point of view, so that those who have up to now been sufficiently interested in TV to read up something about it will already have a good grasp of the fundamental processes concerned in dissecting and re-creating an image according to the modern electronic method.

This does not mean that the series of articles of which this is the first, is suitable for serving as an introduction to the subject, for those who have absolutely no prior knowledge of the basic processes of the television system. At the end of this article will be found a short list of references to books which are excellent introductions to TV for radio men. None of them are too highly theoretical in nature, nor are they of the "popular" type which is quite useless to the serious student. It will save us, here, a great deal of unessential explanation if we can assume that the reader already knows the principles of the TV system. Anyone who may find himself at a loss for the meanings of certain TV terms will find all the answers he may need in any one of the recommended books.

Perhaps it would not be amiss to mention at the outset just why we have chosen the British standard TV signal to work with rather than the American or C.C.I.R. specification. The latter, essentially is the 625-line system already chosen by Australia for her service when it comes along, while the American 525-line system is also well known. Perhaps the first reason for choosing the British standard is that its synchronizing signal is rather simpler than that of either of the others, both in structure and in making it. The only fundamental difference between the British standard and the others is that the former does not use the series of half-line equalizing pulses on either side of the vertical synch. pulses. This may not sound like a very great difference, and fundamentally it is not, for the equalizing pulses can well be regarded as a pleasant, but non-essential refinement, but these same equalizing pulses cause complications in the synch. signal generator that are out of all proportion to their usefulness, and make the generator a much more difficult thing to design and build, without adding anything of a fundamental nature. The American 525-line system is not suited to our conditions, because it is based on their A.C. mains frequency of 60 c/sec., and would not fit in with our own 50 c/sec. supply. It is obvious, therefore, that for experimental work such as we are about to indulge in, by far the best choice of standard is the British 405-line system. Besides, there is a good chance that this may become the chosen standard for our own TV service. Should it so turn out, then those who have displayed sufficient interest to build the circuits that will be described will have already built an exceedingly useful piece of equipment that could not be purchased as a going concern for less than several hundred pounds. Should the Government decide on the 625-line standard, then no harm will have been done, because the differences between the two are those of detail only, and not of principle, and the experience gained will certainly not be wasted. Finally, it is the writer's guess that the New Zealand standard will turn out to be the British one, or something very much like it.

THE B.B.C. SIGNAL—FACTS AND FIGURES

The British standard TV waveform is shown in Fig. 1. The picture area is completely scanned by 405 lines in a time of one twenty-fifth of a second. In TV parlance, the *field* is 25 c/sec., and there are 405 lines, interlaced 2 : 1. That is to say, instead of having 25 vertical sweeps per second, during each of which there are the full 405 horizontal sweeps, we have 50 vertical sweeps a second, during each of which only half the lines are produced. Whichever way we have it, there are still the same number of lines produced per second, but what we have done by interlacing is to give ourselves twice the number of vertical sweeps per second. The purpose of this is to reduce flicker. With the lines themselves, there is absolutely no question of flicker, since their frequency is so high, but if there were only 25 vertical sweeps per second, flicker would be very apparent. Doubling the rate reduces the flicker to negligible proportions. Interlaced scanning is most readily

THE BBC TELEVISION WAVEFORM

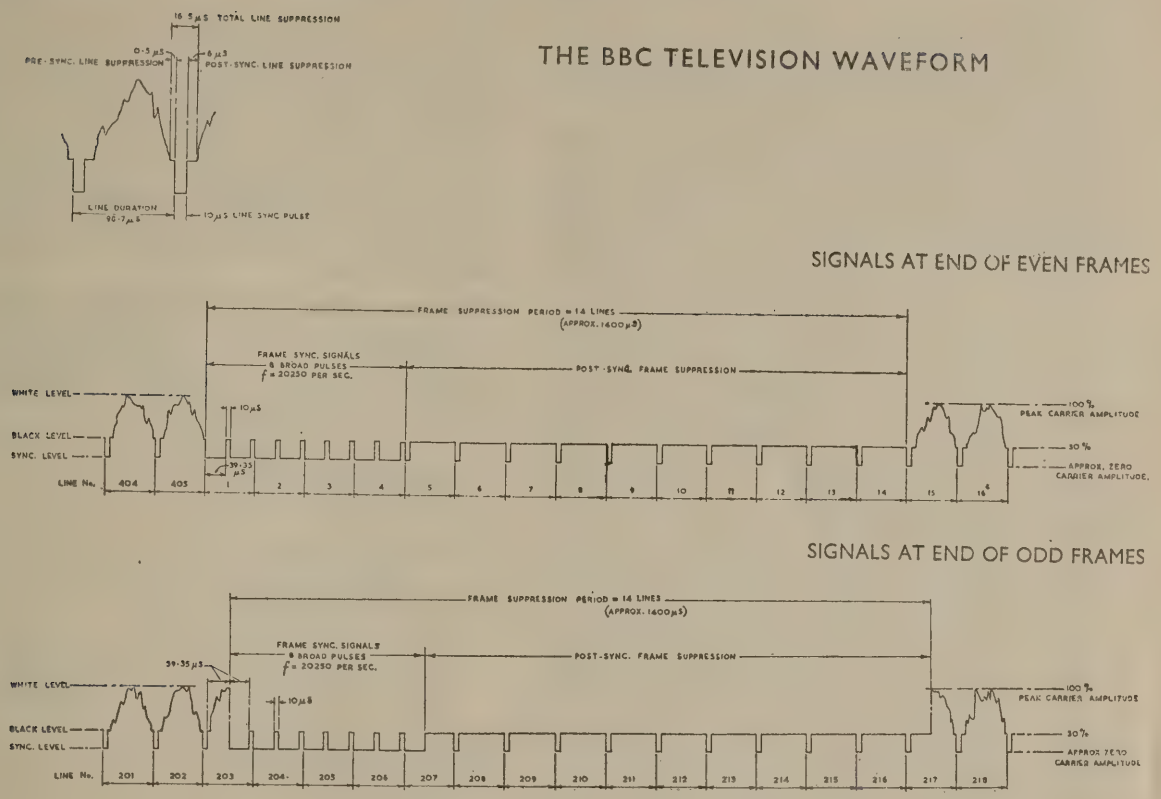

Fig. 1.

likened to a book which is printed in such a way that lines 1, 3, 5, etc., must first be read, down to the bottom of the page, after which we go up to the top again and read lines 2, 4, 6, etc., down to the bottom again. In television, as in a book, all the lines have to be seen, so that those which are scanned the first time down the page (even frames) must lie evenly between those scanned on the second trip down it (odd frames). Now on account of the interlacing system, we must have *two* vertical movements of the C.R.T. spot for every complete field of 405 lines. How are things to be arranged so that the lines of one frame do come exactly in between those of the other? If there were an even number of lines, then each frame would contain a whole number of complete lines, too, and it would be necessary to introduce some special circuit in both the camera tubes and the receiver's C.R.T.s which would shift the spot vertically by half the distance between the lines of one frame. While this would be possible, it would certainly be very difficult to do with the necessary accuracy, and a much surer way of producing interlacing is needed. For the viewer, one of the worst TV faults to put up with is the "pairing" of the lines that results from improper interlace.

The method used is to have an odd total number of lines. In the British case, there are 405 lines per field. There are two frames per field, so that each frame contains 202½ lines. Thus, each vertical scanning movement of the spot is initiated by a synch. pulse after 202½ lines have been traced in the horizontal direction. On one frame, the vertical synchronization takes place at the beginning of a line (which can be called Line 1 for ease of reference) while on the next, vertical synch. is effected half way through Line 203. Because of this, the spot will start its second vertical sweep from a point that is half a line-space lower than the point from which it started the first sweep of the field. In this way, interlacing is automatically obtained, provided only that the vertical synch. circuit in the receiver is triggered by exactly corresponding portions of all vertical synchronizing signals. In cheaper receivers, where special vertical synch. circuits are not always used, it is fairly common to observe pairing of the lines to a greater or lesser extent. It is to make the receiver manufacturer's job easier that the American and C.C.I.R. synchronizing signals include the equalizing pulses, whose function is to make all vertical synch. signals appear identical to the receiver's vertical time-base circuit, irrespective of whether the synch. signal starts at the end of a line (even frames) or in the middle (odd frames). However, there are a number of circuits available which make it possible to achieve virtually perfect interlace in the receiver, so that the equalizing pulses are not absolutely essential.

The drawings in Fig. 1 show even the minute details of the synchronizing signals. The most obvious feature of the signal is the train of narrow horizontal synch. pulses. These are 10 μsec. long, and take place at the beginning of each line. Their frequency is 10,125 c/sec., which follows from the fact that there

are 405 lines in each complete picture, and that there are 25 pictures each second. Thus, the number of lines per second is $25 \times 405 = 10{,}125$. One line, therefore lasts for 1/10,125 sec., or 98.7 μsec.

Now although the camera produces video signals continuously, it is not desirable that these should be transmitted the whole time. In the first place, there should not be any video signal transmitted during the 10 μsec. periods occupied by the horizontal synch. signals. If there were, the synch. signal's shape would be distorted. Secondly, it is desirable to prevent video signals from being transmitted for short periods just before and just after each horizontal synch. signal. Accordingly, the video signals are suppressed, or blanked, as the Americans have it, for a short time which starts 0.5 μsec. before each synch. pulse, and ends 6 μsec. after it. In the transmitter, this is done by mixing with the video signal a train of pulses, at the line frequency, but 16.5 μsec. in length, and commencing 0.5 μsec. before the synch. pulses. When this is done, the resulting mixed waveform is also clipped at a fixed reference level, which represents picture black right through the system thereafter. All this can be seen in Fig. 1, and is really quite simple. By far the most complex part of the signal is the vertical synchronizing portion of the waveform. In order to make room for it, the video signal is suppressed for 14 lines. The first four of these are used for the vertical synch. pulses, while during the remaining ten lines, only the line pulses appear. In the middle diagram of Fig. 1, it can be seen that the frame synch. signals consist of eight broad pulses, each lasting 39.35 μsec., and followed by a gap of 10 μsec. Since the eight broad pulses occur during four lines, their frequency is exactly twice the line frequency. Another way of regarding the frame synch. signal is to look at it as a single wide pulse, lasting 398.4 μsec. (= four lines exactly) and broken up by eight 10 μsec. pulses which are in opposite polarity to the line pulses. It is the different behaviour of circuits towards pulses of different lengths that enables the line and frame synch. signals to be separated in the receiver. In the bottom drawing of Fig. 1, it is seen that the synch. signal for the odd frames is exactly similar to that for the even frames, the only difference between them being that the latter start at the beginning of a line, while the former start exactly half way through a line. This applies both to the frame blanking period, and to the four-line frame synch. period, so that both these also end half-way through a line on the odd frames. The reason for the gaps, or serrations, in the four-line frame synch. pulse is as follows. The receiver contains two time-bases, both of which must be kept in synchronism at all times. If we use four lines (or rather the time occupied by four lines) in order to synchronize the frame time-base, we cannot afford to have the line time-base slipping out of synchronization in the meantime. Thus, the frame synch. signal must take such a form that while it is going on, line synchronising still goes on too.

In the diagrams, the whole TV signal has been drawn with the synch. signals shown as negative-going. This is because in the British system, maximum transmitter output corresponds to white in the picture, 30 per cent. of maximum represents picture black, and zero output is reached during the synch. pulses. Thus, amplitudes between zero and 30 per cent. of maximum are reserved for the synch. signals. Accordingly, the start of a synch. signal always goes in the negative direction, from greater to smaller amplitude. It is the front edge of each synch. pulse that is used at the receiver to trigger the line time-base, so that during the frame synch. pulse, there must be a negative-going edge, occurring at a time corresponding with the leading edges of the line synch. pulses that are missed out. The 10 μsec. notches that are cut in the frame pulse do not harm the usefulness of the latter for triggering off the frame time-base, but they do enable the synchronization of the line time-base to be kept going, until after the frame pulse has finished, and the line pulses proper start again.

MAKING THE SYNCHRONIZING SIGNAL

Now that we have had a look at the synchronizing waveform we hope to make, it should be possible to gain some idea of how we are to go about it. Basically, the general scheme is not so very frightening, and looks something like this:

Steps Required

(1) Line Blanking Pulses
Pulses 16.5 μsec. long, at line frequency of 10,125 c/sec.

(2) Line Synch Pulses
Pulses 10 μsec. long, also at line frequency, but starting 0.5 μsec. after those of (1).

(3) Frame Blanking Pulses
Pulses approximately 1,400 μsec. long, at frame frequency of 50 c/sec., and timed so that every other one starts exactly at the beginning of a line. The remaining ones will then automatically start exactly half-way through a line.

(4) Frame Synch. Signals
Pulses 39.35 μsec. long, at twice line frequency, i.e., 20,250 c/sec.

(5) Means for Mixing (1) and (3)
This gives the composite blanking signal.

(6) Means for Selecting Frame Synch. Signals
From the continuously generated pulses in (4) some means must be provided for selecting only the eight which start with the one which begins at the same time as the frame blanking pulse.

(7) Means for Selecting Line Synch. Pulses
From the continuously generated line synch. pulses of (2) all are selected except the four which occur during the frame synch. pulses.

(8) Means for Mixing (7) and (6)
When the selected pulses from steps (6) and (7) are mixed, we have the composite synchronizing signal.

The above list sets out the eight fundamental processes that must be gone through, giving two outputs, the composite blanking signal and the composite synchronizing signal. If at this stage one had a source of video signal, such as a camera tube or a monoscope, an additional two mixing operations involving only the waveforms already made, would give the composite video signal shown in Fig. 1.

OTHER THINGS ARE INVOLVED

While the list of eight processes is comprehensive and final, it leaves certain features of the equipment to the imagination. For example, it says nothing about how the basic frequencies (line and frame) are to be generated, or how they are to be kept in exact relationship to each other. It is self-evident that the line frequency must always be *exactly* $202\frac{1}{2}$ times the frame frequency if the lines are to be

stationary on the picture. This means that we must have some way of locking one frequency from the other. Also, are we to use the 50-cycle mains as our standard frequency, and make the line frequency from it, or what? Will it be satisfactory if the frame frequency is not exactly equal to that of the mains, as long as the strict relationship between line and frame frequencies is maintained? None of these questions are dealt with in the Eight Points, but whatever the answers, it is obvious that some additional equipment must be involved. There are a number of possible ways of solving these problems, but those chosen are as follows:

numbers, which must not be too high, since high division ratios are difficult to deal with.

When the circuits have been set up that produce the same frequency from twice the line frequency, the question arises as to whether or not the whole system is to be tied to the mains frequency. It does not have to be, since the transmission contains all the essential information to enable the receiver to produce a synchronized picture, but it is advisable to do so. The reason is our old friend 50-cycle hum. In a TV set, just as in a sound receiver, hum is always present for one reason or another. In a TV picture, it will cause alternate light and dark bars to show on the

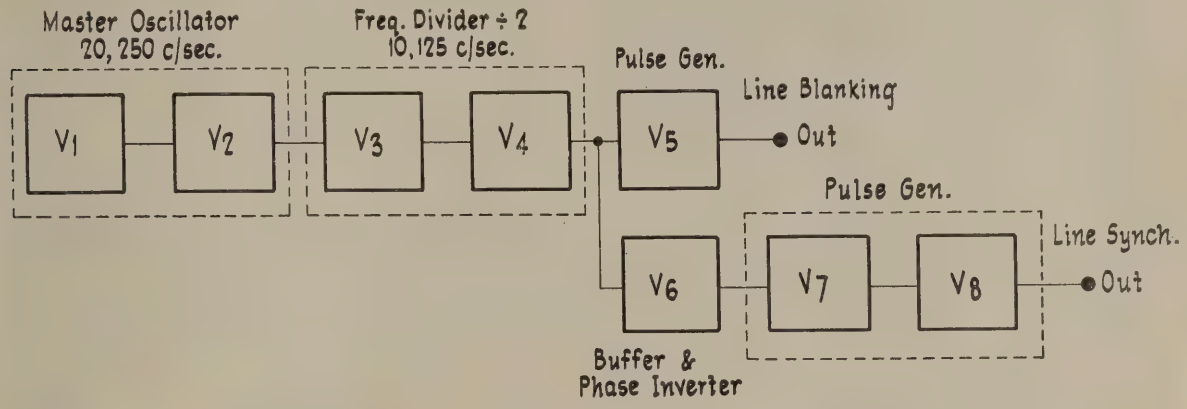

Fig. 2.

FREQUENCY GENERATION AND LOCKING

The method about to be described is basically the one which is commonly used in television transmitting equipment, but will probably differ from commercial methods in several particulars, since we have not been influenced in any way in the choice of design features, except perhaps by the desire to make everything as easy as possible, consistent with stable and satisfactory performance.

Instead of generating either the line or the frame frequency directly, this equipment starts by generating in an oscillator a frequency of 20,250 c/sec., or twice the line frequency. Then, in order to preserve a strict relationship between the line frequency and the frame frequency, which must also be generated in the equipment, a chain of frequency dividers is used, giving a total division of 405 times. This will give the frame frequency of 50 c/sec., and explains why it is necessary to start with twice the line frequency. To get 50 c/sec. from 10,125 c/sec., the line frequency, it would be necessary to divide by 202½, which though not impossible, is difficult of attainment. It is much easier, therefore, to start at twice the frequency and divide by 405. This number can be factored as follows: $3 \times 3 \times 3 \times 3 \times 5 = 405$, thus making it possible to perform the required frequency division by means of a series of frequency dividers dividing by three and five. Or, three dividing stags, dividing by 9, again by 9, and then by 5 would give the same result.

This, incidentally, shows why the numbers of lines chosen for TV systems always seem as if they had been picked at random. The number must be odd (where the field frequency is 50 or 60 c/sec.) and must also be able to be factorized into odd prime

picture if it is great enough to be noticeable. Now if the "50-cycle" frame frequency derived from the master oscillator at the transmitter is not exactly the same frequency as the 50 cycles of the mains, any hum bars that are seen will be moving slowly up or down the picture area. If the frame frequency is locked to the mains frequency, then the bars will be stationary. Observation has shown that if the hum bars are stationary, they can be much greater in intensity before they become noticeable than if they are moving. It is thus of considerable assistance to the maker of receivers if the two frequencies are synchronized. It is of assistance to the public, too, because anything which makes the lot of the manufacturer easier reduces the price of his receivers!

Thus, some means will have to be provided of synchronizing the frame frequency with that of the mains. This is usually done by comparing the two in a discriminator circuit, similar to an A.F.C. circuit or an F.M. detector, and using the resulting D.C. control voltage to control the frequency of the twice-line-frequency master oscillator. However, for present purposes, this will be reserved till late in the series of articles, although the master-oscillator to be used is designed with an eye to the future necessity of controlling it.

In Fig. 2 is drawn a block diagram of a portion of the circuit. The sub-blocks indicate the individual valves. It will be seen that in the first eight valves are included the master oscillator, which is a free-running multivibrator, and the circuits which produce the line blanking pulses and the line synchronizing pulses. Since the master oscillator works at twice line

(Concluded on Page 48.)

SHOES and SHIPS

"The time has come," the Walrus said,
"To talk of many things. . . . "

By Special Arrangement with the Walrus

Special Car Radios

At the present moment there are plenty of car radios available in all shapes and sizes, but motor-car manufacturers being what they are, attempt to make even more resplendent dashboards for their cars than ever before. Admittedly, these ornate facias generally make provision for a radio set somewhere, but all too frequently the dial cutout and control knob position provided will not fit any specific make of set. Consequently, the proud owner of a thousand-odd pounds' worth of new motor-car finishes up with a radio tucked underneath the facia panel or otherwise jammed into the space provided in a "press-on-regardless" manner. The job is unsatisfactory from the beginning for a discriminating owner who accepts the position but doesn't feel very happy about it.

From the point of view of the radio serviceman, who is hard pressed for enough hours in the day to do his work, there is little he can do but for those with the time and the inclination to build a special set for their own car or a favoured customer the job is not too difficult. From the point of view of the set itself, by using the well-known range of miniature valves in conjunction with one of the high-gain coil kits now available, the performance is almost assured. The actual constructional features, however, will be dictated by the space provided in the car for fitting a radio. Usually this is adequate, for it should be borne in mind that where it is sometimes not possible to have a deep set, owing to the distance between facia panel and engine bulkhead, it is still possible to extend the width of the set and accommodate all the components that way. The real problem is the dial movement, but a little ingenuity can overcome this also. As an example, a description will be given of a set that was specially built to fit a 1948 Austin 16 and then later converted to fit a 1952 Vanguard. The Austin was a very awkward job in that no provision for a radio had been made with the exception of a speaker grille underneath the dashboard. The only conceivable position for the set was on the driver's side between the steering column and the door and slung underneath the dash panel. This introduced further trouble in that the set could not project down to any extent without fouling the driver's knee. The set could have been placed over on the passenger's side, but the same problems prevailed and it would have been too difficult for the driver to reach. The set was eventually built to be mounted well back underneath the dashboard and the dial movement made very shallow and carried forward on long angle brackets so as not to interfere with leg room as shown in Fig. 1.

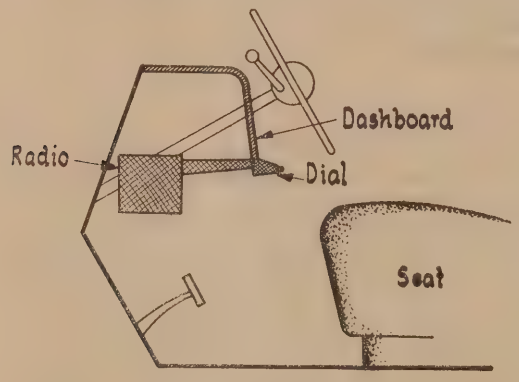

Fig. 1

The actual dial movement was made by taking a conventional glass scale of a well-known coil-kit manufacturer and cutting it down with a glass cutter to leave just the broadcast frequency calibrations. An exploded diagram of the construction of the dial is shown in Fig. 2, and while it involved a lot of shaping and fitting, the result was eminently satisfactory and made a neat and professional-looking job. The actual exposed part of the dial movement was covered in brown leatherette to match the rest of the car. The dial housing was made just deep enough to enclose the dial scale, which lay almost horizontal, and the control knobs, which were carried forward from the set itself on long extension shafts. This arrangement gave good service for many months and then the owner changed his car to a Standard Vanguard and insisted on installing the same set in the new car. Now the Vanguard had a very nice escutcheon for a radio provided right in the centre of the dashboard. Obviously, the Austin arrangement was not going to work out here so the existing dial movement was dismantled. The set was then tried in the correct position in the Vanguard and was found to fit in nicely if turned sideways. This meant bringing a dial movement around on the side of the set with provision for tuning and volume control. The dial drum being round the corner from the actual dial, the cord drive had to be taken "round the bend" by two long roller pulleys, although it

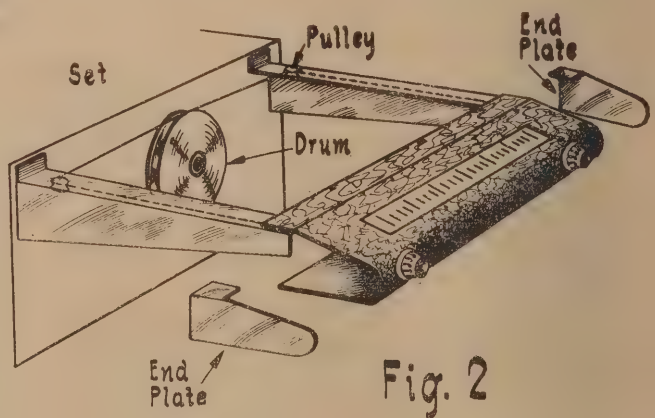

Fig. 2

could have ben done by two small separately mounted ones. The whole set when placed in position allowed the two control knobs to protrude through the dial

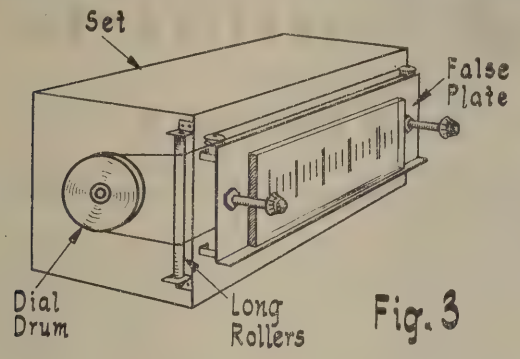

Fig. 3

opening on the facia panel. Two masking plates were found necessary to fill the gaps at either end of the dial where control control shaft came through and this was done by fitting two suitably shaped plates of aluminium, machine-finished, at each end. The machine finishing was done something in the nature of an experiment by securing some fine emery paper round a piece of ¼ in. brass rod. This was put in a drill press and lowered on to the aluminium sheet at regular close spaced intervals to give a series of whorls. The whole effect was most pleasing when finished, particularly with the dial scale edge-lit in the approved manner.

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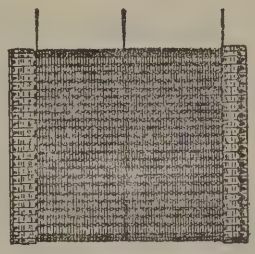

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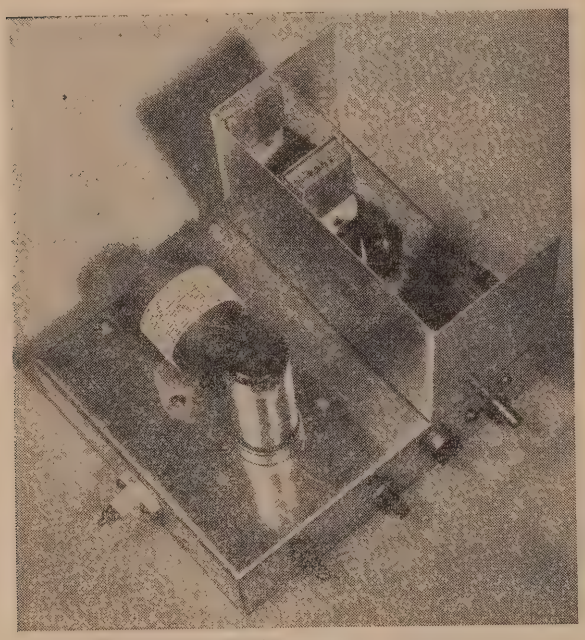


CONSTRUCTION AND ADJUSTMENT OF THE TRANSMITTER

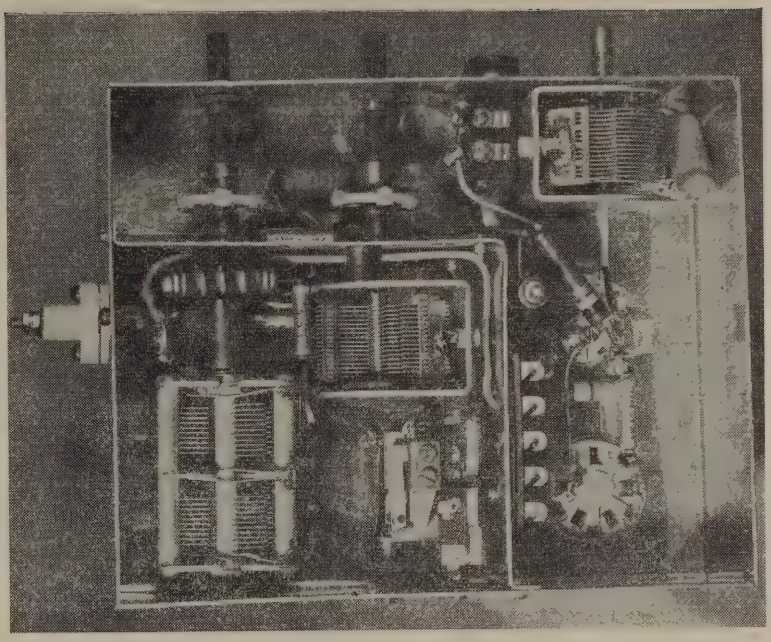
The photographs and diagrams printed here give a good idea of the construction of the transmitter, whose circuit was described in last month's instalment. The chassis is 7 in. × 5½ in. × 1¾ in. deep, and is made from 18-gauge aluminium sheet. There are two baffle shields, one above and one below the chassis. Their purpose is to isolate the input and output circuits of the QQC04/15, which works as a straight amplifier, and would be liable to instability unless proper shielding were employed. The under-chassis shield crosses the socket of the final amplifier valve, and the compartment so formed in the left-hand back corner of the chassis contains all the component parts of the output tank circuit. It also houses the send/receive change-over relay, whose main function is to act as an aerial change-over relay. At the same time, a second set of contacts switch on the filament of the QQC04/15 when the Send/Receive switch, which will be in the receiver, is in the Send position. This takes advantage of the quick-heating properties of the filament, to cut down the steady drain on the operating battery. In the circuit diagram, it will be noticed that the relay has not been shown as such .The aerial switch, S_1 represents one set of contacts, while the terminal E goes to one contact of the second pair. The circuit has been drawn in this way in order to cater for those who do not wish to go to the expense of an aerial relay. In this event, S_1 can be a manually-operated switch, for which room can be found on the transmitter chassis if necessary, and the terminal E can be taken to one set of contacts on the Send/Receive switch in the receiver. Readers will probably notice that one of the variable condensers in the output tank compartment is one of the midget Polar two-gang units. The reason for this is that, as shown in the circuit diagram, a maximum capacity of 150 $\mu\mu$f. was required here, but these midgets are not made with single sections as large as this. It was necessary, therefore, to use a two-gang, with capacities of 75 $\mu\mu$f. per section, and to connect the sections in parallel. The large condenser is also a Polar metal-frame variable of the kind often erroneously called a "single gang," and has a maximum capacity of approximately 540 $\mu\mu$f. At this point we should correct an error that crept into the circuit diagram. The tuning condenser for L_1, the oscillator plate coil, is not 100 $\mu\mu$f., as marked, but is actually one of these same Polar 540 $\mu\mu$f. condensers.

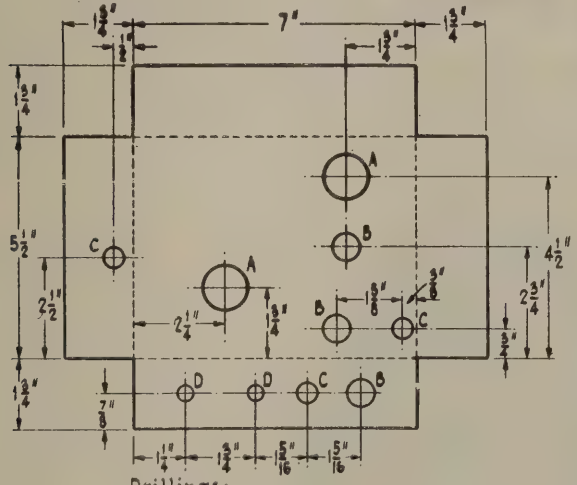
The oscillator coil, L_1, does not plug in, but is a fixture, and it is tuned to either 80m. or 40m. simply by changing the tuning capacity. There is a compromise here, in that doing this results in a somewhat unfavourable L/C ratio on both bands; this reduces the maximum grid drive obtainable from the oscillator, but since there is still more than enough for the final, this does not matter, and by making the compromise, we have eliminated one plug-in coil—a worth-while saving both for construction and for ease of operation.

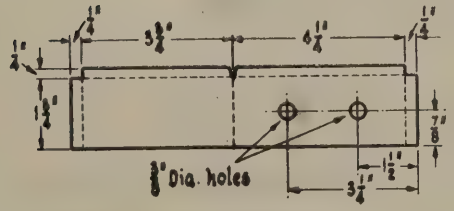
The final tank coils, however, do plug in, and are mounted on two Belling-Lee banana sockets. The banana plugs are mounted on the coil formers, with nuts provided with the plugs, and solder-lugs are used as washers, and to terminate the coils.

The oscillator coil cannot be seen properly in the top-chassis photograph, but it is mounted in the following way. The tuning condenser is mounted by its three screws to the front of the chassis, and a hole ⅜ in. in diameter is made in the chassis opposite the point where the stator solder lug comes. Since the chassis is so shallow, this lug almost projects through the chassis, and it is used as a support for one end of the coil. The latter is wound on a 1 in. diameter piece of former, and riveted solder lugs are fixed at the ends of the coil-former as terminations for the wire of the coil. A piece of stiff copper wire, about 20-gauge, and about an inch long is soldered to the lug at one end so that it projects vertically

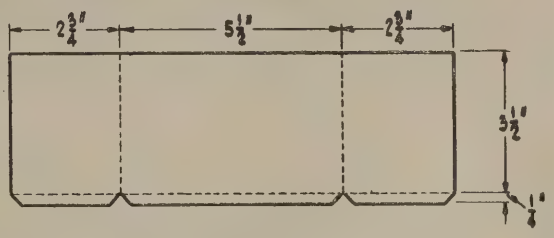
for the wire of the coil. A piece of stiff copper wire, about 20-gauge, and about an inch long is soldered to the lug at one end so that it projects vertically downwards when the coil former is horizontal. The end of the stiff wire is soldered to the lug of the tuning condenser, and forms the support for one end. For the other end, a small stand-off insulator, with about $\frac{3}{4}$ in. of porcelain is mounted above the chassis, and the terminating lug of the coil is soldered to another lug- gripped by the nuts on the stand-off insulator. Under the insulator is a $\frac{3}{8}$ in. hole in the chassis, so that the wire from the plate pin of the EG91 can be brought through, and clamped under the head of the insulator's bolt. This converts the insulator into a satisfactory feed-through and makes it unnecessary to use a two-piece feed-through insulator of the usual kind, which would take up rather too much space under the chassis.







Working drawings for chassis and both shield partitions.



When marking out the chassis material, it is worth noting that the $1\frac{1}{8}$ in. hole at the back of the chassis was used in the original, simply to accommodate a crystal-holder which requires an American 5-pin socket. If this, or an octal socket is needed for the type of crystal-holder it is proposed to use, all will be well, but if any other type of crystal mounting is to be used, this hole may not be needed.

The wiring is carried out in a straight-forward manner, with the R.F. bypass condensers placed as close as possible to their respective places in the circuit. For example, it is important to place the 0.02 μf. bypass at the top end of the oscillator coil as close to the tuned circuit as possible, remembering that this condenser is really included in the tuned circuit. Because of this, it should be returned not to any convenient point on the chassis, but directly to the stator of the 500 $\mu\mu$f. tuning condenser. In the original, some very peculiar behaviour of the final grid current was finally traced to the fact that this condenser was (a) not large enough, and (b) not connected in this way. The trouble is that if it is taken to the chassis, even a short distance from the earthing point for the variable condenser, the chassis between the two earth points becomes part of the tuned circuit, and considerably increases the losses. The position of the key jack is clearly seen in the

(Continued on Page 47.)

No. 2.

LABORATORY NOTES

FROM

BEACON RADIO LIMITED

FLUORESCENT LAMP BALLASTS

For quite a number of years now Beacon have made fluorescent lamp ballasts and supplied large quantities to the trade. Beacon ballasts are giving satisfaction from one end of New Zealand to the other.

In common with other technical processes, the manufacture of ballasts presents a number of problems. The maintenance of a quality article free from hum and giving the best possible electrical characteristics consistent with physical size is always in mind. The facilities of the Beacon laboratory which is equipped with Weston sub-standard instruments for checking on ballast performance assist in the production of a first-class article. Every ballast that leaves the factory has been individually tested for performance. Statistical quality control is used during the manufacturing process to check such things as the quality of the silicon steel core material and adjustment of the component parts of the ballast.

Beacon are pleased to discuss technical problems that may arise through the use of fluorescent lamps and associated equipment. Rapid advances are being made in the lighting field. The dealer often has to evaluate some new development without much information to guide him. The Beacon technical library which forms part of the laboratory may contain just the answer that he is looking for. In any case the experience of our technicians may have covered the point.

In two further advertisements important technical aspects of ballast operation will be mentioned.

BEACON RADIO LIMITED

CORNER BROWN AND FITZROY STREETS, PONSONBY, AUCKLAND

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MANUFACTURERS OF ALL TYPES OF TRANSFORMERS AND FLUORESCENT LAMP BALLASTS

The "RADIO and ELECTRONICS" Abstract Service

AERIALS AND TRANSMISSION LINES

An interesting discovery has been made that under certain conditions skin effect losses of a transmission line can be much reduced by laminating the conducting surfaces parallel to the direction of current flow with alternate thin layers of conducting and insulating material. The thickness of each conducting layer must be smaller than the skin depth in the conductor, and phase velocity is critical.

—*Bell System Technical Journal* (U.S.A.), Sept. 1952, p. 883.

In waveguide work it is often necessary to reduce standing waves resulting from a discontinuity some distance away. In the method described, a portion of the incident energy is taken off by the directional coupler into a separate arm. By proper adjustment of the phase and amplitude of the voltage returned to the waveguide by the coupler, it is possible to reduce the original standing wave over a band of frequencies.

—*Proceedings of the I.R.E.* (U.S.A.), October, 1952, p. 1216.

AUDIO EQUIPMENT AND DESIGN

Intermodulation distortion—the article illustrates this form of distortion with reference to effects on a piano. In testing the amplifier high or low pass filters, and a rectifier are used. Simple mathematical examples are given to illustrate and calculate the results with a view to improvement of the amplifier.

—*Audio Engineering* (U.S.A.), October, 1952, p. 21.

The author presents a simple and easily understood concept of the effect of feedback or input and output impedances of tubes. The use of negative feedback began in the early days of the art to effect neutralization, but there is still some disagreement as to the manner in which gain reduction takes place, impedance changes of tubes within the loop, and mathematical procedure for determining the improvement. The simple mathematics of the systems are given—effect of increasing feedback—reduction of noise and distortion, etc.

—*Ibid*, p. 23.

A design for clean base—the modern idea of extending the treble must be accompanied by a corresponding extension of the base, but it is easy to get a false base effect with annoying boom. Cabinets on the lines of the exponential horn are therefore being developed, and one more design is given, whereby nearly a full octave has been added, and the results are described as amazing.

—*Ibid*, p. 29.

A discussion on the violin (continued). Many will be surprised at the intricacies of the instrument, and the article deals with the bridge, the construction of the body, the bass bar, sound post, and their resonances and vibration.

—*Ibid*, p. 34.

CIRCUITS AND CIRCUIT ELEMENTS

It is common knowledge that the bistable vacuum-tube device referred to as the Eccles-Jordan flip-flop was first described in 1919, but the inventors used batteries. The general problem of design is complex, but a graphical design technique is given which should prove helpful in other switching circuit design problems using a large number of identical direct-coupled circuits.

—*Electrical Engineering* (U.S.A.), October, 1952, p. 905.

ELECTRONIC DEVICES

A regulating system is part of many electrical applications, and the magnetic amplifier is a flexible element in many systems. Numerous outstanding advantages of the device are given which make possible faster, simpler, and more stable systems.

—*Ibid*, p. 912.

Ferroelectric storage elements for digital computers and switching systems. Such a device can store up 2,500 bits of information per square inch of surface only a few thousandths of an inch thick, with pulses less than a microsecond long. The basic ferroelectric memory circuit is described, which can hold the information for long periods without degeneration.

—*Ibid*, p. 916.

A further article on digital computors—in the machine described magnetic drum storage is used, and information is given on multiple shift instructions, the multiplier, the function table, and the control.

—*Electronic Engineering* (Eng.), October, 1952, p. 442.

The Clavioline is a small electronic musical instrument which is melodic and can sound only one note at a time, is of three octaves only, and is suitable for attachment to a piano. Many different tonal effects can be obtained from the 18 stops, and the weight of the instrument is some 46 pounds.

—*Ibid*, p. 454.

A very appealing toy in the form of a blinking light is described. The circuit makes use of the principle of a capacitor charging and discharging through a resistor to provide a reliable timing device for turning neon lights off and on. The circuit is adjusted to three or four neons and will work from a 90-volt battery with very small current drain, and is also of very simple construction.

—*Ibid*, p. 461.

INSTRUMENTS AND TEST GEAR

The time when Geiger counters were used in laboratories is now past, and the instrument is used for warning of radioactivity, and in searching for active ores. The article deals with the history of the device, the principles upon which it works, the counter apparatus wherein halogen gases are used for statistical quenching.

—*Philips Technical Review* (Holland), Vol. 13, No. 10, p. 282.

The development is described of a phototube phospor combination for radiation detection. The detector utilizes the average current from the phototube rather than pulses as from the scintillation counter type detector. The resulting instrument is stable, has a very fast time constant as compared to either ionization-chamber or Geiger tube instruments, and is lightweight and rugged.

—*Electrical Engineer* (U.S.A.), October, 1952, p. 935.

All alternating current bridge measurements stem from the work of Max Wien who described the Wien Bridge. The article deals with the present day adaptions of the bridge, frequency response, the relative mathematics, unbalanced connections, and its uses for distortion measurement, wave analysis, and the general scope of its application.

—*Electronic Engineering* (Eng.), October, 1952, p. 450.

MATERIALS, VALVES, AND SUBSIDIARY TECHNIQUES

A study of the characteristics of glow-discharge voltage regulator tubes (Part 2). This article deals with photoelectric effects, operation with reversed polarity, striking voltage, effects of tube age, current overloads, exposure to magnetic and electric fields, etc.

—*Ibid*, p. 456.

Capacitors with vacuum dielectric are particularly suitable for high-frequency high-voltage operation in airborne equipment. In addition, the capacitor has low power consumption, high current carrying capacity and long life. At low ambient pressure, external breakdown occurs, so that special construction is necessary.

—*Proceedings of the I.E.E.* (Eng.), September, 1952, p. 307.

Refinements in crystal-unit processing technique have made it desirable to re-examine the quartz-crystal frequency spectrum in search of designs which show maximum stability. By utilizing the overtone frequency of specially shaped AT-cut quartz plates, both Q and the rate of impedance change with frequency are enhanced together, and the stability increased. Crystal oscillator stabilities of one part in one hundred million per month have been achieved without recourse to stabilized circuits.

Proceedings of the I.R.E. (U.S.A.), September, 1952, p. 1030.

Electrical noise in semi-conductors—transistors, diodes, and single crystal filaments have common noise properties. Theoretical attempts to explain the noise are reviewed briefly, and experiments indicate that the noise resides in the behaviour of the minority carrier. It is not yet clear whether the noise is a surface or a volume property of the material, but it is well established that the surface properties have an important connection with noise.

—*The Bell System Technical Journal* (U.S.A.), Sept, 1952, p. 950.

There are numerous electronic applications in which it is desirable to vary the phase angle of a low frequency sinusoidal voltage by means of a manual control—for instance, in the delay of the firing point of thyratrons. A basic circuit is given, but the standard circuit which uses a centre-tapped transformer has limitations of control. Variations of the basic circuit are given for better control, and phase shift of over 180°. A circuit is also given for automatic control, and combined automatic and manual control.

—*Electronic Engineering* (Eng.). October, 1952, p. 462.

Trustworthy valves are frequently mechanical redesigns of commercial types intended to provide improved performance under vibration and shock. The causes of failures of commercial types are examined and redesigns are made to avoid existing weaknesses. A survey of world progress has been made with notes of the techniques necessary to assist this progress.

—*Proceedings of the I.R.E.* (U.S.A.), October, 1952, p. 1166.

MATHEMATICS

The wave equation can be solved numerically with a resistance-network analogue by feeding in currents at the mesh nodes, and making adjustments to the fed-in currents until the solution has become "self-consistent." In this way the electromagnetic field distribution within cavity resonators and waveguides can be found, and the resonance frequencies of various shapes can be predicted.

—*Proceedings of the I.E.E.* (Eng.), Sept., 1952, p. 316.

PROPAGATION AND MODULATION

A development is taking place in telecommunications in that speech and music are being transmitted by means of a pattern

(Concluded on Page 48.)

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P26

TUBE DATA: The Double Tetrode QQC04/15

DESCRIPTION

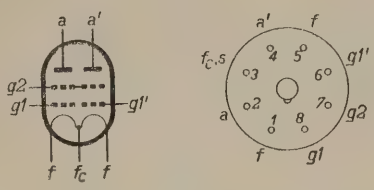
The QQC04/15 is a double tetrode transmitting tube capable of providing an output of 20W. at 186 mc/sec. and of 8W. at 300 mc/sec. This tube is not only entirely satisfactory for all normal transmitting purposes, but embodies in its design, features which have been incorporated to answer the additional requirements of mobile transmitting equipment.

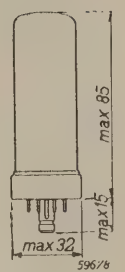
In mobile installations the actual transmitting time is usually a small percentage of the total time that the vehicle, or other such mobile station in which the transmitter is installed, is actually in service. It will, therefore, usually be desired, in order to minimize the average current consumption over a long period, to switch off the filament supply during stand-by operation. When indirectly-heated tubes were used the heater current consumption, however, would not only be high, but the heaters could, in addition, not be switched off during stand-by as indirectly-heated tubes take a rather long time to heat up. For this reason directly-heated tubes are usually employed in those stages that consume the greater part of the total current. It is therefore possible for the filaments of these tubes to be switched off during stand-by, thus considerably reducing the average current consumption over a long period.

The heating-up time of the directly-heated QQC 04/15 is only about two seconds, so that in the time it takes to pick up the microphone and operate this the tube filament has already reached the temperature required for full emission.

Compared with a thoriated tungsten cathode, the oxide-coated cathode used in the QQC04/15 has the advantage of a high degree of insensitivity to filament voltage variations. Whilst the filament of the QQC04/15 is rated for a voltage of 6.3V, current 0.68A., the tube may also be operated with a filament voltage of only 5.5V. This has hardly any effect on the output, provided that the anode voltage is not underrated to the same extent. The useful life of the tube is not affected to any appreciable extent by deviations of the filament voltage of ± 10 per cent.

It is well known that at high frequencies push-pull circuits have various advantages. When two single tubes are employed in such a circuit, it will be difficult to keep the self-inductance of the lead interconnecting the cathodes sufficiently low, to prevent part of the driving power from being fed into the output circuit, especially at high frequencies. The self-inductance of the lead interconnecting the screen grids must also be as small as possible, as otherwise R.F. voltages would occur at the screen grids; such voltages counteract the driving voltages at the control grids. It is obvious that these self-inductances are very small in a double tube such as the QQC 04/15 in which the cathode and the screen grid are common to both sections. The active electrode capacitances are also small in a push-pull circuit, thus providing the possibility of designing high-quality circuits. It is mainly to be attributed to these facts that the double tetrode QQC04/15 in a push-pull circuit is capable of giving an output of 20W. at 186 mc/sec. and of 8W. at 300 mc/sec., with an anode voltage of 300V. It is of special importance for mobile installations that an appreciable output may also be obtained at a low anode voltage. With an anode voltage of only 250V., the QQC04/15 can give an output of 10W. at 186 mc/sec.





In the case of single tubes, two tubes are obviously required in a push-pull stage, and only one double tetrode QQC04/15 is necessary. It is also obvious that the latter will occupy much less space; this being a very important advantage in mobile equipment.

The QQC04/15, although specially designed for push-pull service, may very well be used with both sections in cascade; one example is that of a frequency multiplier. A large multiplication factor can thus be obtained with only one tube. The tube may also be used as an A.F. amplifier in the modulator portion of a transmitter or, in public address equipment which is intermittently used and for which a directly-heated output tube is required.

Mobile transmitters are often operated by personnel having no special training, and the tubes may then have to be replaced by inexperienced hands. In order to minimize the risk of the operator touching live conductors, the QQC04/15 is of single-ended construction. Flexible anode connections are thus avoided, and this is a particularly favourable feature for the reliability of the transmitter. The "all-glass" construction of the tube results in very short and rigid internal connections, thus giving a very rugged assembly and one suitable for operation on wavelengths down to 1m., while the 8-pin (Loctal) base is firmly held by the socket.

TECHNICAL DATA

Filament Data

Heating: direct.

Nominal filament voltage	V_f	= 6.3 V
Filament current	I_f	= 0.68 A

Base Connections and Dimensions in mm.

Mounting position: only vertical with base up or down.

Socket: ceramic type 40213.

Capacitances

One section		
Grid	C_{g1}	= 8.5 pF
Anode	C_a	= 3.3 pF
Control grid to anode	C_{ag1}	= 0.05 pF
In push-pull service		
Input	C_i	= 5.7 pF
Output	C_o	= 1.7 pF

Typical Characteristics

Amplification factor between screen-grid and control-grid	μ_{g2g1}	= 7.5
Mutual conductance of one section at 20 mA anode current	S	= 2 mA/V

OPERATING CONDITIONS

H.F. class C amplifier and oscillator with 2 sections in push-pull.
A. Continuous service, CCS

Wavelength	λ	5	5	1.6	1.6	m
Anode voltage	V_a	400	250	400	250	V
Screen-grid voltage	V_{g2}	200	175	200	175	V
Grid bias	V_{g1}	—80	—70	—80	—70	V
Anode current	I_a	2 × 30	2 × 30	2 × 30	2 × 30	mA
Screen-grid current	I_{g2}	5	5.5	5	5.5	mA
Grid current	I_{g1}	2 × 1.4	2 × 1.8	2 × 1.3	2 × 1.4	mA
Driving voltage peak-to-peak	$V_{g1g1'p}$	210	210	210	220	V
Driving Power	W_{ig1}	2 × 0.14	2 × 0.17	2 × 0.13	2 × 0.14	W
Screen-grid dissipation	W_{g2}	1	1	1	1	W
Anode input power	W_{ia}	2 × 12	2 × 7.5	2 × 12	2 × 7.5	W
Anode dissipation	W_a	2 × 3.2	2 × 2.2	2 × 3.5	2 × 2.5	W
Output power	W_o	17.6	10.6	17	10	W
Efficiency	η	73	71	71	67	%

H.F. class C amplifier and oscillator with 2 sections in push-pull.
B. Intermittent service, ICAS.

Wavelength	λ	5	5	1.6	1.6	m
Anode voltage	V_a	400	250	400	250	V
Screen-grid voltage	V_{g2}	200	175	200	175	V
Grid bias	V_{g1}	—80	—70	—80	—70	V
Anode current	I_a	2 × 40	2 × 40	2 × 40	2 × 40	mA
Screen-grid current	I_{g2}	6	6.5	6	6.5	mA
Grid current	I_{g1}	2 × 2	2 × 2.3	2 × 1.8	2 × 2.1	mA
Driving voltage peak-to-peak	$V_{g1g1'p}$	220	230	220	230	V
Driving Power	W_{ig1}	2 × 0.2	2 × 0.24	2 × 0.17	2 × 0.22	W
Screen-grid dissipation	W_{g2}	1.2	1.2	1.2	1.2	W
Anode input power	W_{ia}	2 × 16	2 × 10	2 × 16	2 × 10	W
Anode dissipation	W_a	2 × 4.4	2 × 3.3	2 × 5.6	2 × 3.8	W
Output power	W_o	23.2	13.4	20.8	12.4	W
Efficiency	η	72.5	67	65	62	%

Class C frequency tripler with 2 sections in push-pull.
A. Continuous serivce, CCS

Wavelength	λ	4.8/1.6	4.8/1.6	m
Anode voltage	V_a	400	250	V
Screen-grid voltage	V_{g2}	200	200	V
Grid bias	V_{g1}	—175	—175	V
Anode current	I_a	2 × 24	2 × 30	mA
Screen-grid current	I_{g2}	3	6	mA
Grid current	I_{g1}	2 × 0.6	2 × 1.1	mA
Driving voltage peak-to-peak	$V_{g1g1'p}$	430	430	V
Driving power	W_{ig1}	2 × 0.12	2 × 0.22	W
Screen-grid dissipation	W_{g2}	0.6	1.2	W
Anode input power	W_{ia}	2 × 9.6	2 × 7.5	W
Anode dissipation	W_a	2 × 6	2 × 5.2	W
Output power	W_o	7.2	4.6	W
Efficiency	η	37.5	31	%

Class C frequency tripler with 2 sections in push-pull
B. Intermittent service, ICAS

Wavelength	λ	4.8/1.6	4.8/1.6	m
Anode voltage	V_a	400	250	V
Screen-grid voltage	V_{g2}	200	200	V
Grid bias	V_{g1}	—175	—175	V
Anode current	I_a	2 × 32.5	2 × 40	mA
Screen-grid current	I_{g2}	4	6.5	mA
Grid current	I_{g1}	2 × 1.1	2 × 1.5	mA
Driving voltage peak-to-peak	$V_{g1g1'p}$	430	430	V
Driving power	W_{ig1}	2 × 0.22	2 × 0.3	W
Screen-grid dissipation	W_{g2}	0.8	1.3	W
Anode input power	W_{ia}	2 × 13	2 × 10	W
Anode dissipation	W_a	2 × 8	2 × 6.9	W
Output power	W_o	10	6.2	W
Efficiency	η	38.5	31	%

Class C frequency doubler, one section
A. Continuous service, CCS.

Wavelength	λ	3.2/1.6	3.2/1.6	m
Anode voltage	V_a	400	250	V

Screen-grid voltage	V_{g2}	200	200	V
Grid bias	V_{g1}	—175	—175	V
Anode current	I_a	30	30	mA
Screen-grid current	I_{g2}	1.5	2	mA
Grid current	I_{g1}	1.2	1.5	mA
Driving voltage peak value	V_{g1p}	210	220	V
Driving power	W_{ig1}	0.23	0.3	W
Screen-grid dissipation	W_{g2}	0.3	0.4	W
Anode input power	W_{ia}	12	7.5	W
Anode dissipation	W_a	5.5	3.5	W
Output power	W_o	6.5	4	W
Efficiency	η	54	53	%

Class C frequency doubler, one section.
B. Intermittent service, ICAS

Wavelength	λ	3.2/1.6	3.2/1.6	m
Anode voltage	V_a	400	250	V
Screen-grid voltage	V_{g2}	200	200	V
Grid bias	V_{g1}	—175	—175	V
Anode current	I_a	40	40	mA
Screen-grid current	I_{g2}	2.5	3	mA
Grid current	I_{g1}	1.5	2	mA
Driving voltage peak value	V_{g1p}	220	230	V
Driving power	W_{ig1}	0.3	0.42	W
Screen-grid dissipation	W_{g2}	0.5	0.6	W
Anode input power	W_{ia}	16	10	W
Anode dissipation	W_a	8	5.1	W
Output power	W_o	8	4.9	W
Efficiency	η	50	49	%

A.F. amplifier in class B, 2 sections in push-pull

Anode voltage	V_a	250		400		V
Screen-grid voltage	V_{g2}	175		200		V
Grid bias	V_{g1}	—17.5		—24		V
Load impedance between anodes	$R_{aa'}$	8160		16,640		Ω
Driving voltage peak-to-peak	$V_{g1g1'p}$	0	62	0	74	V
Anode current	I_a	2 × 9	2 × 30	2 × 4	2 × 27	mA
Screen-grid current	I_{g2}	20	17	7.5	21	mA
Grid current	I_{g1}	0	2 × 0.9	0	2 × 1.2	mA
Driving power	W_{ig1}	0	2 × 0.03	0	2 × 0.04	W
Screen-grid dissipation	W_{g2}	3.5	3	1.5	4.2	W
Anode input power	W_{ia}	2 × 2.25	2 × 7.5	2 × 1.6	2 × 10.8	W
Anode dissipation	W_a	2 × 2.25	2 × 3.4	2 × 1.6	2 × 2.8	W
Output power	W_o	0	8.2	0	16	W
Total distortion	d_{tot}		5		5	%
Efficiency	η		55		74	%

H.F. class C amplifier with anode and screen-grid modulation, 2 sections in push-pull.
A. Continuous service, CCS.

Wavelength	λ	5	1.6	m
Anode voltage	V_a	250	250	V
Grid bias	V_{g1}	—70	—70	V
Screen-grid resistor	R_{g2}	10	10	kΩ
Anode current	I_a	2 × 19.5	2 × 19.5	mA
Screen-grid current	I_{g2}	11	11	mA
Grid current	I_{g1}	2 × 1.5	2 × 1.5	mA
Peak driving voltage	V_{g1p}	110	110	V
Driving power	W_{ig1}	2 × 0.15	2 × 0.15	W
Screen-grid dissipation	W_{g2}	1.6	1.6	W
Anode input power	W_{ia}	2 × 4.9	2 × 4.9	W
Anode dissipation	W_a	2 × 1.8	2 × 1.9	W
Output power	W_o	6.2	6	W
Efficiency	η	63	61	%
Modulation depth	m	100	100	%
Modulation power	W_{mod}	5	5	W

H.F. class C amplifier with anode and screen-grid modulation, 2 sections in push-pull.
B. Intermittent service, ICAS.

Wavelength	λ	5	1.6	m
Anode voltage	V_a	250	250	V
Grid bias	V_{g1}	—70	—70	V

Screen-grid resistor	R_{g2}	10	10	kΩ
Anode current	I_a	2 × 26.5	2 × 26.5	mA
Screen-grid current	I_{g2}	9	9	mA
Grid current	I_{g1}	2 × 1.8	2 × 1.5	mA
Peak driving voltage	V_{g1p}	110	110	V
Driving power	W_{ig1}	2 × 0.18	2 × 0.15	W
Screen-grid dissipation	W_{g2}	1.5	1.5	W
Anode input power	W_{ia}	2 × 6.6	2 × 6.6	W
Anode dissipation	W_a	2 × 2.5	2 × 2.7	W
Output power	W_o	8.2	7.8	W
Efficiency	η	62	59	%
Modulation depth	m	100	100	%
Modulation power	W_{mod}	7	7	W

Limiting values

			continuous service CCS	intermittent service ICAS	
Anode voltage	V_a	= max.	400	400	V
Screen-grid voltage	V_{g2}	= max.	250	250	V
Negative grid voltage	$-V_{g1}$	= max.	200	200	V
Grid current	I_{g1}	= max.	2 × 5	2 × 5	mA
Cathode current	I_k	= max.	80	100	mA
Peak cathode current	I_{kp}	= max.	480	600	mA
Anode dissipation	W_a	= max.	2 × 6	2 × 8	W
Screen-grid dissipation	W_{g2}	= max.	7	7	W
Grid dissipation	W_{g1}	= max.	2 × 0.25	2 × 0.25	W
External resistance between grid and cathode	R_{g1}	= max.	150	150	kΩ
Pin temperature		= max.	100	100	°C
Bulb temperature		= max.	200	200	°C

The Portable Receiver Tester Type TF888.

Why not a *personal* Signal Generator for your design engineers — especially a portable instrument operating from interchangeable mains or battery units and covering the wide frequency range of 70 kc/s to 70 Mc/s. So much more preliminary work can be done without waiting for the standard laboratory apparatus to be free or moved from one bench to another. And if the *personal* Signal Generator also incorporates its own crystal check plus a useful power meter—all at the cost of one inexpensive instrument—each engineer is equipped at all times to carry out his own experimental tests. To such facilities add a reliable accuracy of output and frequency calibration and you have the portable Receiver Tester — the ideal laboratory sub-standard. Full technical data is freely available.

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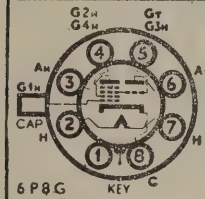
6P8G now implies that Service men must

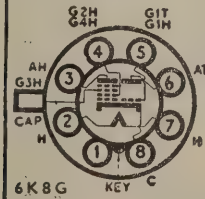
*BRIMARIZE

Remember to *BRIMARIZE is to improvise by utilizing an equivalent when a particular valve-type is unavailable.

TYPE	CHANGE SOCKET FROM	CHANGE SOCKET TO	CHANGE CONNECTIONS FROM OLD SOCKET	CHANGE CONNECTIONS TO NEW SOCKET	OTHER WORK NECESSARY	PERFORMANCE CHANGE
6K8G	INT/OCTAL NO CHANGE		NO CHANGE		REALIGNMENT WILL BE NECESSARY	SLIGHTLY REDUCED GAIN

RATED CHARACTERISTICS





	6P8G	6K8G	
Heater Voltage	6.3	6.3	Volts
,, Current	0.8	0.3	Amps
Anode Voltage	250	250	Volts
,, Current	2.2	2.5	mA.
Screen Voltage	80	100	Volts
Osc. Anode Resistor	50,000	40,000	Ohms.
Conversion	0.65	0.35	mA/V.
Hexode Input Capacity	7.5	5.5	m.m f.d.
Hexode Output Capacity	21.5	5.5	,,
Osc. Input Capacity	17	7.0	,,

Both 6P8G and 6K8G are triode-hexode types with International Octal bases, and no change of connections will be necessary. The inter-electrode capacitances of the two types are different however, and it will be necessary to realign the oscillator and I.F. circuits after Brimarizing.

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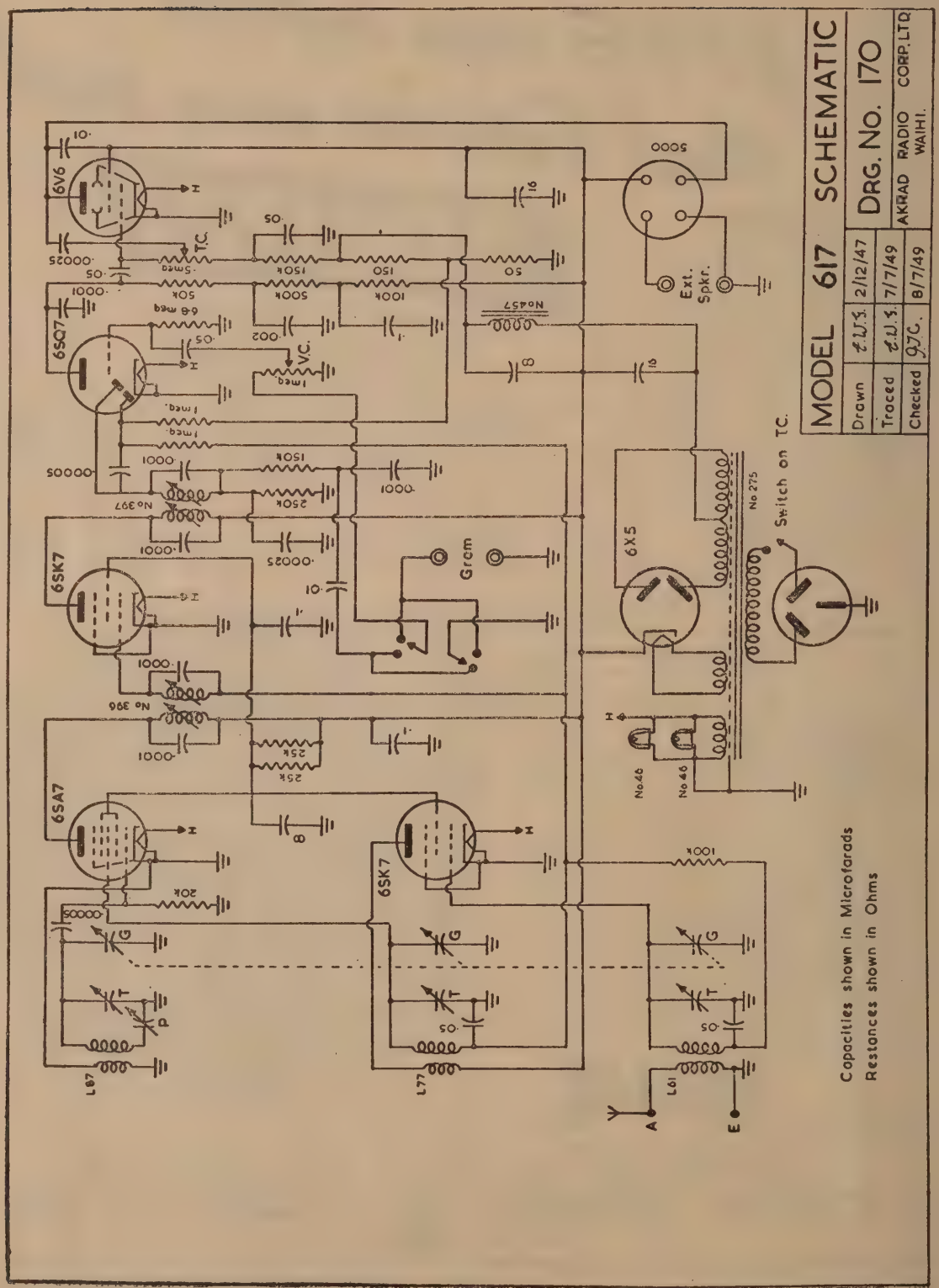
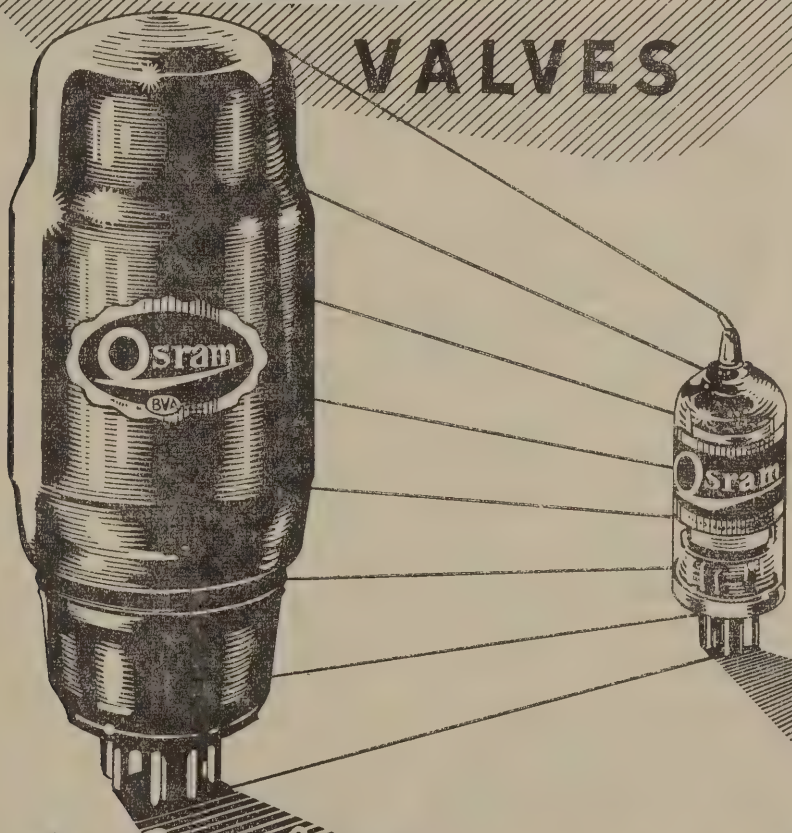


Osram

VALVES



A tonic to any set

BRITISH GENERAL ELECTRIC CO. LTD.

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The Application of Selective Calling to Party Line Radio-Telephone Circuits—Part II

By R. MOTION and C. H. STURTON (N.Z.P.O.)

Valve V_1, Fig. 4, now functions as a timing network to apply these tones for a period of five seconds to the transmitter line through the hybrid network and modulate the transmitter.

When the timed five-second period is finished the tones are disconnected and transmitter and receiver lines are connected to the operator who answers the called subscriber and connects him via the operator's cord circuit to the calling subscriber.

The hybrid network consists of a pair of transformers TR_1 and TR_2 so connected that speech or noise originating in the receiver is attenuated in the circuit between receiver and transmitter but passes with little attenuation from receiver to line or from line to transmitter. The object of this connection is to prevent recirculation of speech or noise around the radio network with consequent deterioration of the signal-to-noise ratio, or the setting up of feed-back singing.

On the conclusion of a call, supervisory lamps are lit in front of the operator; the radio circuit lamp being controlled by the A.V.C. in the base station receiver.

A call originating in the radio network lights a calling lamp in front of the toll operator as soon as the calling subscriber operates his transmitter, the calling lamp being connected to a relay operated by the A.V.C. in the base station receiver. The toll operator answers and dials the wanted number in the normal manner.

Calls from one radio telephone unit to another, on the same radio cannot be operated duplex and provision for this type of call is made by unbalancing the hybrid network, thus connecting the base station receiver and transmitter together.

The subscribers then operate by the "press to talk" method.

The disadvantage of the "press to talk" system is not likely to be serious in practice as the "car to car" type of call will seldom be required and in any case, both the calling and called party will be familiar with the operating technique.

The telephone exchange equipment, therefore, serves to connect a telephone subscriber with a radio-telephone subscriber or vice versa, the intermediatory operation being via the normal "toll' board; the originating of a call being no different to the procedure used for normal short distance toll calls. The time taken for connection is very small as the "in" and "out" calls will be simple dialled calls on the part of the "toll" operator.

MOBILE STATION EQUIPMENT

The requirements for this part of the system were outlined earlier in this article and a unit capable of fulfilling these requirements has been developed and proved satisfactory in practice. The schematic diagram is shown in Fig. 5 and a general view of the unit in Fig. 6. (See Part I of this article.)

The output of the radio receiver in the mobile radio station is applied via the contacts of relay RD to the primaries of the two resonant transformers TR_1 and TR_2 in series. On receipt of the pair of tones to which the transformers are resonated, relatively high audio frequency voltages are built up across the secondaries of these transformers. Tones of frequency other than the wanted ones produce very little voltage across these sharply resonant circuits.

Valve V_1 is a double diode which has a high D.C. delay voltage applied via the voltage divider R_2, R_3, and the diodes do not conduct except on receipt of an audio frequency tone from the resonant transformers of sufficient amplitude to overcome the delay voltage. When the diodes conduct the resultant rectified D.C. is applied as negative bias to the grids of V_2, a double triode operated normally at zero bias and with the plate current limited by R_{13}. With sufficient negative bias applied to the two grids of V_2 the plate current is cut off, relay RA releases and rings the call buzzer in the control box.

Valve V_2 operates in a simple manner to guard against false calls by reception of one tone only. If only one section of V_2 is biased off, the plate current of the other section increases and the current through RA remains practically constant.

The time constants R_6, C_5, R_7, C_6, are included to reduce the chance of high bursts of noise producing false calls and in this respect the high selectivity of the resonant circuits, plus the use of delay voltage to V_1 and the time constant mentioned, provides adequate protection against any level of interference that may be encountered in practice.

In the circuit shown, the extra relays RB, RC, RD, and valves V_3, V_4, provide facilities which although not a part of the selective calling are desirable additions to ensure satisfactory circuit operation.

Valves V_3 and V_4 operate as D.C. amplifiers to amplify the receiver A.V.C. voltage and operate relay RB whenever a carrier is received. The contacts of relay RB complete a circuit for a "busy" lamp in the control box which indicates to the subscriber when the channel is in use. Contacts RB_2 of the same relay also prevent the subscriber from starting up his transmitter and heterodyning a conversation if the channel is in use.

Should a call be received when the subscriber is temporarily absent, the "call" lamp will remain lit until the subscriber returns; this is provided for by the operation and locking up of relay RC. Relay RD, besides other functions, changes over the receiver audio line from the decoder unit to the handset when a call is answered or initiated. This relay also prevents a call, once initiated, from being overheard by any other subscriber on the channel as the other subscribers are effectively locked out by their own A.V.C. operated relay interlock circuit.

The actual operation may be detailed as follows:—

Incoming Call.—Valve V_2 is biased off by the incoming ringing tones and relay RA releases completing a circuit for the buzzer via the contacts RA_1, and also for relay RC via contacts RA_1 and RC_1.

The buzzer sounds and relay RC operates locking up over its own contacts, RC_1 and contacts RD_1.

The "call" lamp lights as it is in parallel with relay RC.

Subscriber Answers.—When the handset is lifted the hook switch contacts close, operating relay RD via the contacts RC_2.

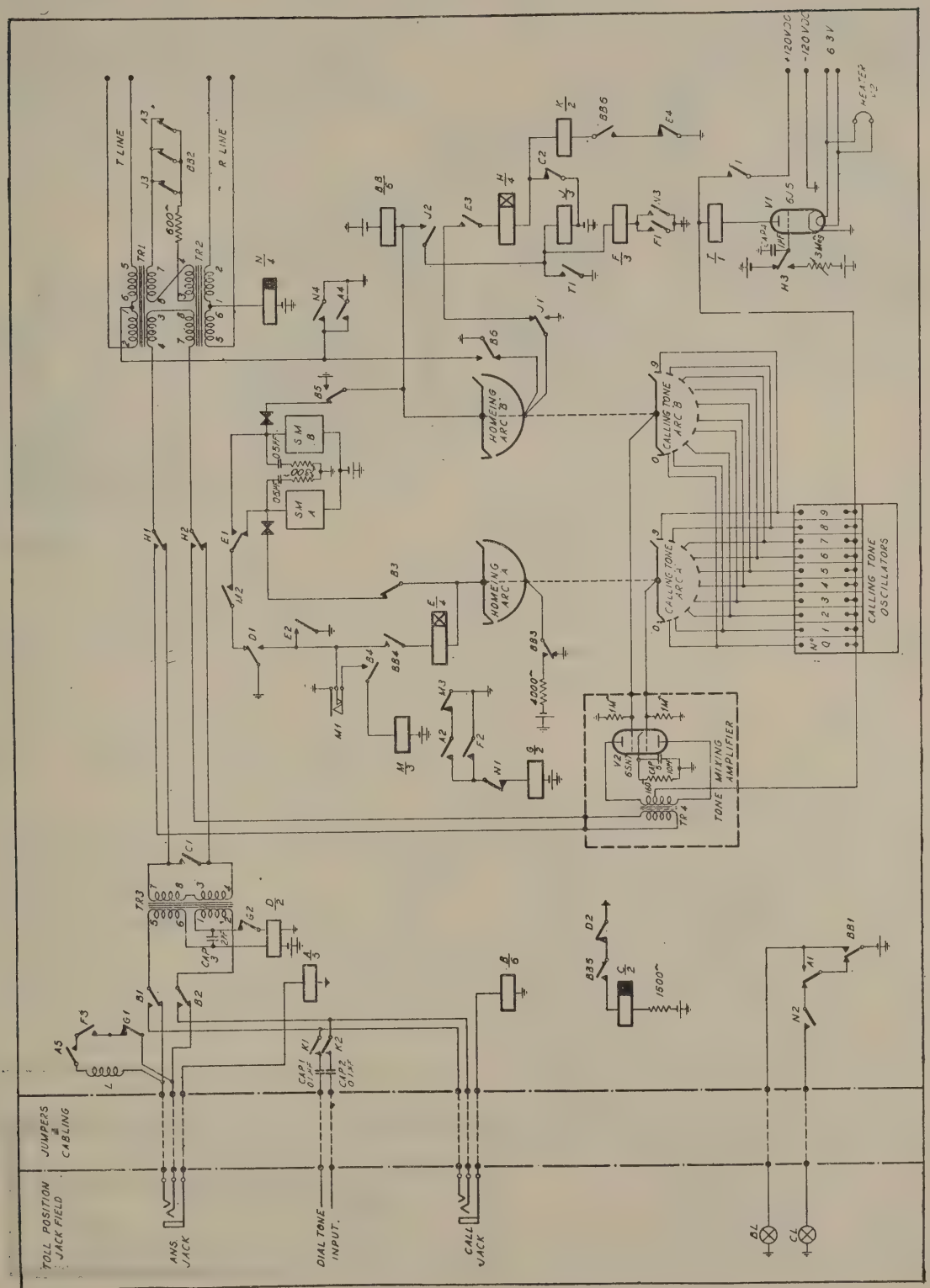
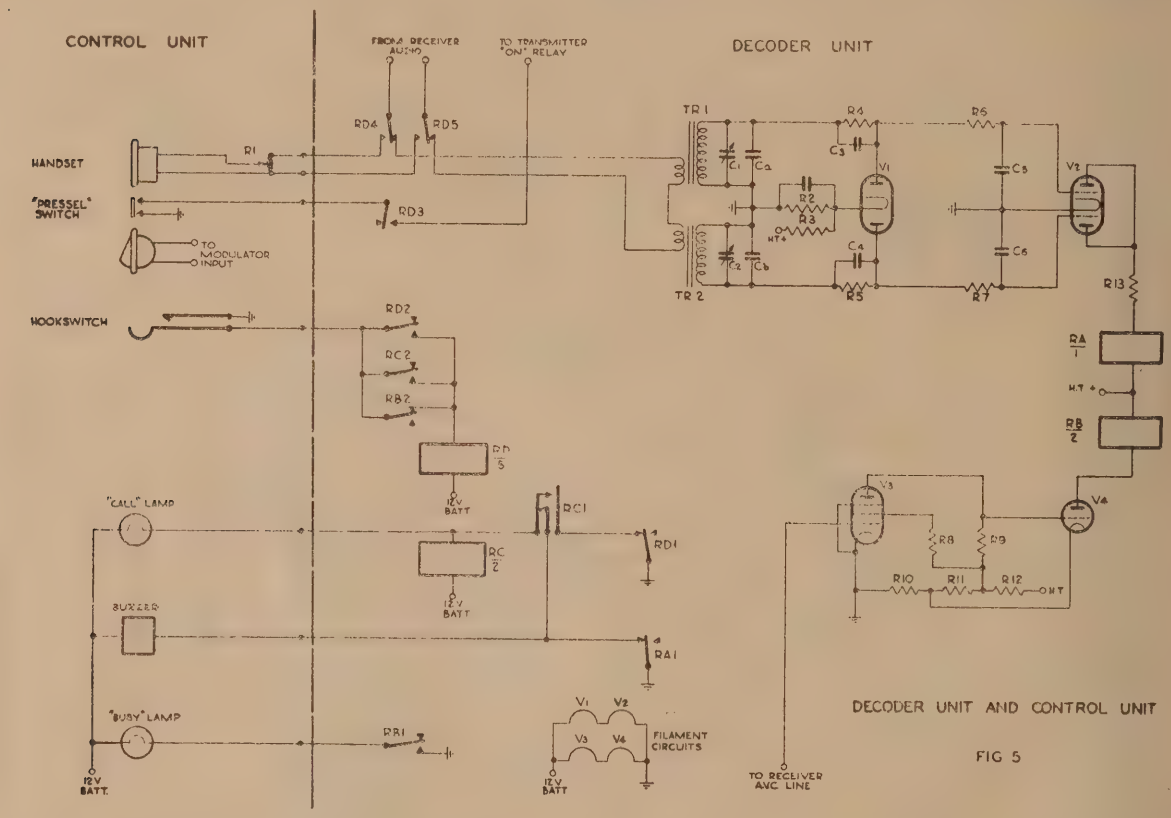


Fig. 4.—Telephone exchange unit schematic (22365A)

Relay RD operates and releases relay RC extinguishing the "call" lamp, and contacts RD_4 and RD_5 change over the receiver audio line to the handset.

Relay RD also completes a circuit via contacts RD_3 to allow the transmitter to be switched on when the "pressel" switch on the handset is operated.

The sensitivity of the decoder unit is such that it will receive calls even under conditions where the noise level is so high that speech operation is impossible and with the receiver heavily overloaded the distorted tone outputs still operate the decoder; no trouble being experienced with false calls due to harmonics or intermodulation components. It is confidently anticipated, therefore, that the system will perform satisfactorily in full-scale operation either as a mobile telephone service, or as a radio-telephone service in remote localities.



DECODER UNIT AND CONTROL UNIT

FIG 5

Subscriber Initiates a Call.—When the handset is lifted relay RD operates via the back contact RB_2. This changes over the audio line to the handset and allows the transmitter to be switched on when the "pressel" switch is operated.

The transmitted carrier received at the base station operates a relay which brings in a lamp in front of the operator who plugs in and answers.

The circuit operation as detailed above is very straightforward and maintenance is therefore simplified. In the construction of this type of decoder the only critical components are the resonant transformers TR_1 and TR_2. These transformers are wound on "Ferroxcube" pot cores which are assembled in their clamps and thoroughly impregnated to prevent shift of any part with vibration. The resonating condensers C_a and C_b are composed partly of negative temperature coefficient (ceramicon) and partly of zero temperature coefficient condseners (silvered mica) to give an overall temperature coefficient approaching zero. A small trimmer condenser is fitted to allow of final frequency adjustment.

CONCLUSION

The equipment as described has been tested under actual operation, with varying temperature and climatic conditions for a considerable period and has performed satisfactorily in all respects.

ACKNOWLEDGMENT

The authors desire to thank the Chief Engineer, New Zealand Post Office, for permission to reproduce details of this equipment which has been developed and tested in the Radio Section, Chief Engineer's Office, New Zealand Post Office.

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THE E.M.I. LIGHTWEIGHT BATTERY-OPERATED MAGNETIC TAPE RECORDER TYPE L/2

Messrs. H.M.V. (N.Z.) Ltd. are pleased to announce that E.M.I. factories are now producing a lightweight battery operated magnetic tape recorder Type L/2. Distribution will be handled by their trade division, E.M.I. Suppliers, P.O. Box 296, Wellington, to whom all inquiries should be addressed.

Further details on application to E.M.I. Suppliers, P.O. Box 296, Wellington, 162-172 Wakefield Street.

The Model L/2 is designed for applications where extreme portability is desired, such as mobile commentating, interview work, etc.

The complete recorder measures only 14 in. x 7 in. x 8 in., weighs 14½ lb. including all batteries, and is housed in a wooden case, green rexine covered, with a shoulder carrying strap.

The equipment uses normal 5 in. diameter spools containing 600 ft. of standard ¼ in. tape, and is available in three versions having operating speeds and playing times as follows:—

Model L/2A, 3¾ in./sec, 30 minutes playing time.
Model L/2B, 7½ in./sec., 15 minutes playing time.
Model L/2C, 15 in./sec., 7½ minutes playing time.

Separate recording and replay heads and amplifiers are provided to facilitate monitoring from tape during recording and to enable the tape to be replayed on site, if desired, to ensure that the required material has been satisfactorily recorded; but it is intended that recordings will normaly be replayed, edited, etc., on standard studio equipment to prevent wastage of battery life.

The tape is easily and quickly threaded, and is brought up to the heads and driving capstan by two guides and the rubber pressure roller, which are latched into position by a lever on the motor-board. The record/replay switch is also on the motorboard, and pre-selects the desired operation.

Once these two controls have been set, the case lid is closed, and the equipment controlled by the motor on/off switch, situated on the control panel which is recessed in the left-hand end of the case.

The control panel carries sockets for crystal microphone and headphones, and, under a hinged flap, the pre-set gain control, loudspeaker jack for replay purposes, and the meter switch enabling motor, H.T., L.T. and bias volts to be checked on the level meter.

The overall performance of the three versions is as follows:—

Frequency Response

At 15 in./sec.: 50 to 10,000 cycles/sec. (± 2 db.)
At 7½ in./sec.: 50 to 7,000 cycles/sec. (± 2 db.)
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Signal to Noise Ratio

Better than 45 db. (at 1,000 cycles/sec.) *unweighted*, when replayed on an E.M.I. Studio Recorder.

Wow

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The batteries have been carefully selected to be universally available, and consist of ten Eveready type U.2, 1.5-volt cells and two Eveready type B.101, 67.5-volt H.T. batteries. The U.2 cells, providing the motor supply, give an effective life of 1½ operating hours, providing that each 15 minutes of running time is followed by a similar rest period, or three-quarters of an hour if continuously operated. The H.T. batteries give a life of 15 operating hours.

All batteries are readily removable, without disturbing the recorder mechanism, through a detachable flap in the right-hand end of the case. The L.T. cells are contained in a metal carrier which can be easily refilled or replaced as a unit.

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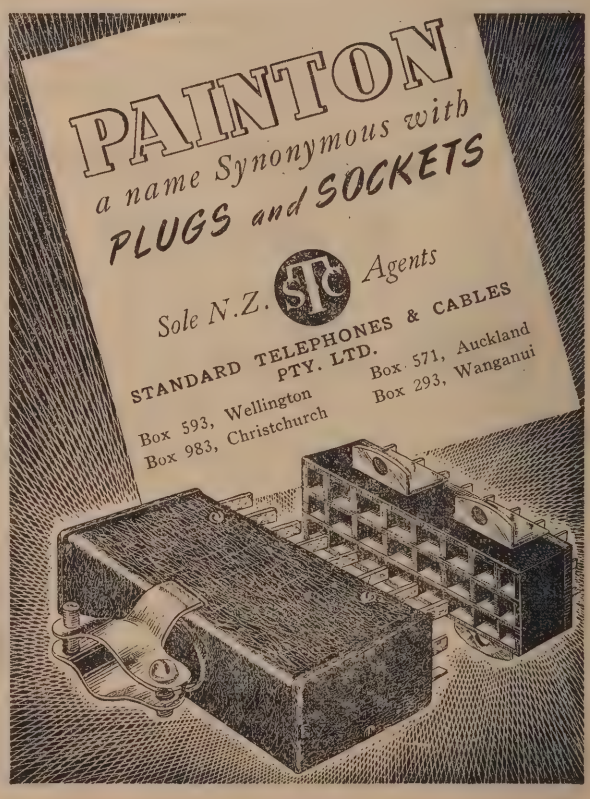

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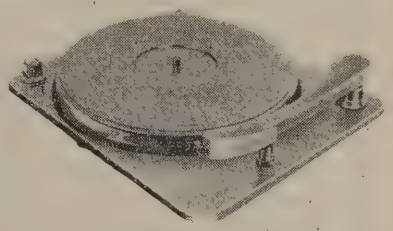

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Personalities

After spending several weeks at the Head Office of the National Electrical and Engineering Co., Ltd., Mr. Ian Malcolm, formerly of the Electrical Engineering Branch of the New Zealand Railways, has rejoined the company's engineering staff, and assumed duty with the Auckland Branch.

* * *

Congratulations to Ken, son of Mr. Jack Cunningham, Manager of the Christchurch Branch of the National Electrical and Engineering Co., Ltd., on his nomination as a Rhodes Scholar.

* * *

National Electrical and Engineering Co., Ltd., just cannot keep out of the news. Now it takes a keen interest in Bill Donovan, son of Mr. R. S. Donovan, Manager of the Wellington Branch, who writes graphically to his parents of his experiences as one of the crew of the ketch *Miru* on its epic voyage from Wellington to Boston, via Peru.

* * *

Proud of his firm's achievements in plastic moulding is Mr. D. T. Clifton Lewis, well-known managing director of Radio (1936) Ltd., whose electric iron handle and the cabinet of the "Ultimette" won first and second prizes respectively in the recent competition held by the New Zealand Institute of Plastics. Radio Limited's exhibits were entered in the Industrial Division of the competition. Prizes in the other divisions were all collected by Plastic Moulders (N.Z.), Ltd., Modern Plastics (N.Z.), Ltd., and Plastic Products Ltd.

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Radiotronics, Vol. 17, No. 17.—Amalgamated Wireless Valve Pty. Ltd.

The National Electrical Review, Vol. 2, No. 3—National Electrical and Engineering Co., Ltd., Wellington.

Westinghouse Engineer, November, 1952.—H. W. Clarke (N.Z.), Ltd.

"Bicalex" Winding Wires—British Insulated Callenders Cables Ltd., London.

G.E.C. Journal, Vol. XIX No. 3, July, 1952—British General Electric Co., Ltd., Wellington.

The N.Z. Manufacturer, Dec./Jan.—N.Z. Manufacturers' Federation.

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Missing and Stolen Radios

Criminal Investigation Branch, Auckland

"Westco" 5-valve car radio, serial No. 11123. Biscuit coloured cabinet 9 in. x 15 in., knob on either side of dial. Letter "W" of "Westco" broken off.

Autocrat 8-valve car radio, crackle finish metal cabinet 9 in. x 5 in. x 3½ in.; 6 in. bracket across cabinet at right angles for fitting to car dashboard. Tuning and volume control white plastic knobs, slide rule dial covered with clear plastic, numbers 55 to 150. 3 ft. of heavy duty flex leading to speaker unit.

H.M.V. broadcast radio, serial No. 11963, model No. 495, green plastic cabinet.

Pacific portable, serial No. 9747, 10 in. x 6 in. lemon-coloured plastic cabinet, Ovalay dial, with speaker covered with four plastic bars built into case.

Criminal Investigation Branch, Hastings

Arnrite battery portable, 5-valve radio, serial No. 777, type No. 815A. Pale blue perspex cabinet, white plastic handle, two white tuning knobs.

Neeco 5-valve battery portable, model 95P, serial No. 49723. Maroon cabinet, plastic back and front, felt sides, top and bottom.

Pacemaker tuning unit car radio, model 7150A, serial No. 95948, 6 volts. Dark brown wrinkle finish cabinet.

Desk type Turner microphone with tilting head, round chromium stem 12 in. high. Black oval stand. Type S.33.D.

Philips 6-valve A.C. battery portable, model 545, serial No. 1750/5007. Brown leatherette cabinet, white plastic speaker grille.

Police Station, Greymouth

H.M.V. 4-valve battery portable. Green plastic badly broken cabinet, 9 in. x 4½ in. x 3 in. with two controls. Interior of set also damaged.

Police Station, Hunterville

Pacemaker 5-valve A.C. portable. Brown cabinet with four control knobs in front.

Police Station, Taihape

Ultimate 7-valve, 12-volt, car radio, serial No. R.B.N. 143794. Oval speaker with golden coloured grille front; separate tuner unit, dark grey with brown plastic front, two white tuning knobs.

Police Station, New Plymouth

Mullard battery/electric portable, serial No. 3791. Mottled brown leatherette case with one bakelite knob, leather carrying strap. Batteries shortly need renewing.

Dunedin

Old, four-valve dry-battery radio, square grey cabinet with round dial.

RADIOS RECOVERED

Criminal Investigation Branch, Napier

Prior 5-valve broadcast No. 7688 and 38387.

Criminal Investigation Branch, Auckland

Golden Knight, 5-valve broadcast, serial No. 577/33.

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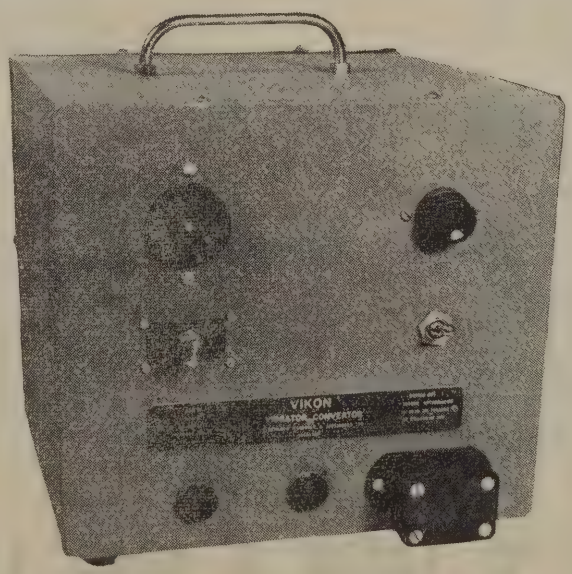

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Proceedings of the New Zealand Electronics Institute Incorporated.

A VISIT TO THE B.B.C.

A visit to the B.B.C. was the title of a talk given to the Wellington Branch of the New Zealand Electronics Institute on 29th October, 1952, by Mr. W. L. Harrison, B.E., B.Sc., A.M.I.E.E., A.M.N.Z.E.I., Chief Engineer of the New Zealand Broadcasting Service.

The subject-matter of this talk was collected by Mr. Harrison while on a visit to the Commonwealth Conference earlier in the year.

HISTORY OF THE B.B.C.

The B.B.C. came into existence about 1923, being commenced by a group representing the principal radio companies, John Reith being appointed the first director of the B.B.C., holding the post of Director-General until the last war. The B.B.C. started as an office on Savoy Hill and now has a staff of about 5,000, which provides sound broadcasting and television for the British Isles and an Overseas Service. The staff of the New Zealand Broadcasting Service is just under 1,000.

SERVICES PROVIDED

The B.B.C. came into existence about 1923. It was 14 medium-wave, high-power transmitters, eight medium-wave, medium-power transmitters, 31 S.W. high-power transmitters, 1 V.H.F. experimental station, and a television service covering five areas throughout the British Isles.

Sound broadcasting is produced from 150 studios, together with 100 outside broadcasts a week. In producing studio programmes, the ratio of rehearsal time to programme time is 8:1, and only 40 per cent. of the programmes are recorded. The majority of recordings are made on discs, but tape recorders are now beginning to replace disc recording.

THE ORGANIZATION OF THE B.B.C.

The major division of the B.B.C. is into an Engineering Division of 500 qualified engineers, 800 assistant engineers, 1,000 technical assistants and the Administration and Secretarial Division of 2,000. The

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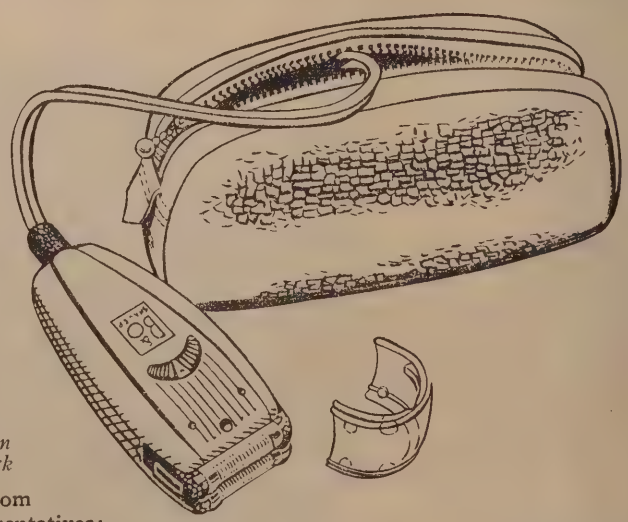

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Engineering Division is then divided into the following separate organisations:—

Sound Broadcasting

OPERATION AND MAINTENANCE

Operating Staff (Shift workers)	Engineering Staff (Fault finding and complex technical maintenance)

Each of these sections is divided into the following sub-sections:

TRANSMITTERS—STUDIOS—LINES

Lines are rented from the B.P.O., all terminal equipment being provided by the B.B.C.

Television

OPERATION AND MAINTENANCE

Sound	Vision	Lighting	Recording

The original television service was commenced before the war at Alexandra Palace, but new studios at Lime Grove, one of the J. A. Rank studios, has been taken over.

Each section of television is subdivided as for sound broadcasting into transmitters, studios, and lines.

The television service covers four areas centred on London, Sutton Coldfield (Manchester), Wales, and Edinburgh.

Vertically polarized radiators are used as opposed to the American practice of using the more efficient horizontally polarized radiators with low-power transmitters. The 750 ft. towers used for TV have a total downthrust of 350 tons and are ball-jointed at the base but not insulated.

The treatment of the studios is usually more primitive than for sound broadcasting, where new studios are elaborately treated for acoustics. Use is made of absorbent blankets held on to the wall by wire netting. Four mobile cameras are used for each studio, these cameras being controlled by the producer, who monitors the four cameras and controls the cross-fading from one to the other. Small studios use two cameras.

The audio equipment is controlled from a separate room which works independently.

A new site has been taken over at Shepherd's Bush for the London area and the transmitters are now being installed.

The high-power television stations are 45 kw. peak for vision and 12 kw. for sound, and others are 10 k.w.p. vision and 3 kw. sound.

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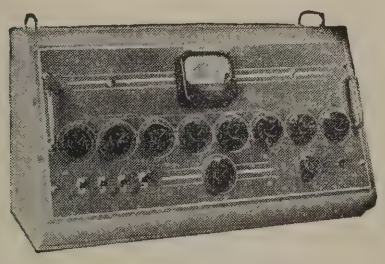
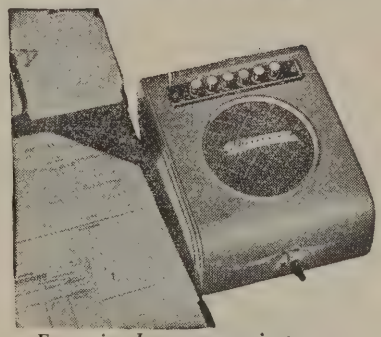


Recording Control Equipment



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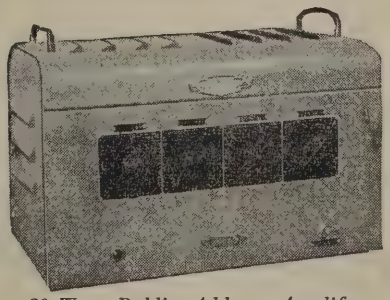
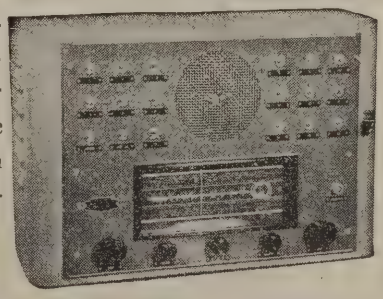


30-Watt Public Address Amplifier



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ENGINEERING AND RESEARCH DIVISION

Research

The engineering and research establishment is situated at Kingsland, 30 miles from London. Among the projects carried out here are applied research in television, including colour television, and aerials, including V.H.F. directional aerials.

This organization has a staff of some 50 engineers.

Projects

The Projects Division carries out the design of equipment and its construction to prototype stage, in the Design Section where a staff of 35 engineers is employed.

The Planning Section of 70 engineers and 40 others prepares specifications for all technical construction.

The Installation Department carries out all new installations.

The Equipment Department is a production department for equipment not produced by outside firms and employs a staff of 350.

The Building Department is responsible for construction of buildings and employs 55 engineers, including civil engineers, and 180 other ranks.

ENGINEERING SERVICES GROUP

This organization is concerned with the information and secretarial side of engineering.

OVERSEAS INFORMATION DEPARTMENT

This department runs receiving stations at Tattersfield and a monitoring station at Caversham, this being mainly a political station.

ENGINEERING SECRETARIAT

This organization does the clerical side of engineering and provides staff for international conferences. A staff of 11 engineers besides other staff is employed.

ENGINEERING TRAINING

The engineering training establishment is situated in an old country home at "Woodnorton," Eversham.

In this establishment specialized training of engineers is carried out together with conversion courses where engineers are trained for other jobs to which they are transferred.

WROTHAM EXPERIMENTAL STATION

An experimental station was set up at Wrotham to determine whether A.M. or F.M. was best for V.H.F. broadcasting, and it has determined that F.M. wins, by a narrow margin.

DAVENTRY EXPERIMENTAL HIGH-POWER STATION

At Daventry, an experimental station has been built, where two 200 kw. transmitters are operated by remote control into one aerial, each transmitter being protected so that it automatically shuts down in the event of a defect appearing, the one transmitter being left to continue the service on reduced power, but arranged so that it still loads into the correct impedance.

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Philips Experimenter

(Continued from Page 25.)

photographs, as can the 10k. screen dropping resistor for the oscillator valve, wired from the jack to the valve socket.

It will be seen that an insulated strip of solder lugs has been attached to the under-chassis shield partition next to the oscillator part of the circuit. This strip of five lugs, is held to the partition by two self-tapping screws, and proper insulation of the back of the lugs is assured by clamping a small piece of fibre insulation between the lug strip and the metal. The lugs are used as terminations for the power supply voltages, and there is no socket or plug for this purpose. The receiver will be mounted directly below the transmitter, so that wires from the power supply lugs on the latter can go down to the receiver, where a plug and socket can take off the leads to the power supply itself.

COIL SPECIFICATIONS

The winding data for the coils needed for the transmitter are as follows:—

Oscillator Plate Coil L_1
17 turns of 30-gauge D.C.C. wire on a 1 in. diameter former, double-spaced.

80m. Final Tank Coil L_2
21 turns of 28-gauge enamelled wire on a 1½ in. former, double-spaced.

40m. Final Tank Coil L_3
13 turns of 20-gauge D.C.C. wire on a 1½ in. former, wound to occupy ⅞ in. of winding space.

TUNING AND ADJUSTMENT

If everything has been made according to specification, there should be very little testing required. Initially, it is a good idea to connect a milliammeter reading 0–10 ma. in series with the grid lead F and the bias battery, so that grid current can be checked before the final is turned on. A crystal is plugged in, and L_1 is tuned to resonance, as indicated by maximum grid current. Needless to say, the filament of the final must be heated for this to be done, so that it will be necessary to hold the relay closed mechanically, if one is used, or electrically, by exciting its coil, using the 6-volt filament battery. The H.T. voltage should be disconnected from the final. When the condenser is tuned, two places should be found at which grid current is obtained. The high-capacity one of these will be 80m., and the low-capacity one, 40m. Initially, it is best to check that this is indeed the case by using an absorption wavemeter. Should anything have slipped, the wavemeter will discover the fact, and save a good deal of hunting at a later stage. Tune up the oscillator on 80 metres, and insert the 80m. output coil in the socket. Attach a resistor of, say, 1000 ohms between the chassis and the aerial terminal to act as a dummy aerial. If a thermo-milliammeter is available, this can be connected in series with the dummy load. Indeed, it is a good plan to buy one if you do not have one about. War surplus Weston 0–100 ma. thermo-milliammeters can be had for about a pound, and are very useful instruments. Alternatively (but not so good) a 15-watt light bulb can be used as the dummy load, and also as an indicator of power output. If the lamp is used, it will be necessary also to tune the absorption wavemeter to the right frequency, and couple it to the final tank coil, to act as an indicator for power outputs that are too small to make the lamp glow. The large condenser in the output circuit is then turned about half-way out, and the 150 $\mu\mu$f. condenser is used to tune the tank circuit to resonance, as indicated by any of the means mentioned. When resonance has been found, make a change in the setting of the large condenser, and retune with the small one, making sure to tune it right "on the nose." Compare the reading on the indicator with the one first obtained. If it is larger, the movement of the larger condenser was in the right direction, and if smaller, it was the wrong way. This indicates which direction the large condenser needs to be moved in to improve the matching between the tank circuit and the load. The procedure is then to keep on making slight changes in the large condenser, retuning each time with the small one, until a setting is found at which any change in the large condenser, in either direction, causes the power output to drop. The load is then properly matched, and if it consists of a resistor with the R.F. milliammeter in series, it will enable the exact power output to be calculated from the relation $W = I^2.R$, where R is the load resistance in ohms, and I is the current through it in amperes. (To be continued.)

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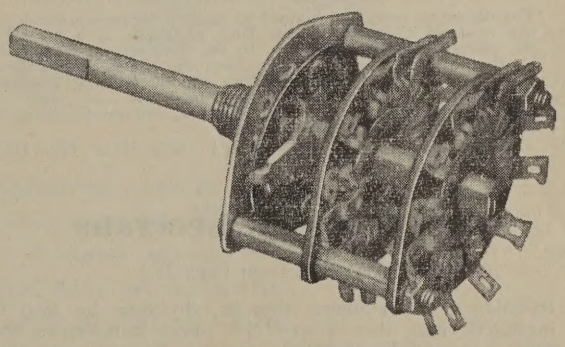

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Abstract Service

(Continued from Page 27.)

of unit signals. The article deals with "delta modulation," in which pulses are produced at the sending end of equidistant instants. An "echelon curve" is formed from the pulses which is compared with the modulating signal. The echelon curve oscillates and approximates to the modulating signal, being the quantized form thereof. A positive step in the curve initiates the transmission of a pulse, whereas a negative step does not, and there is a gap in the transmission at this moment.
—*Philips Technical Review* (Holland), March, 1952, p. 237.

In the past ten years the radio engineer has decreased the wavelength of coherently generated radiation down to little over 1 mm. However, as we proceed to still shorter radiation, it is safe to predict that owing to the increasing opacity of the atmosphere to such radiations, our interest will be more purely scientific. At less than 1 mm. the molecular spectroscopist relies entirely on far infra-red sources, optical elements, such as grating, prisms, etc., and interesting observations are made on the magnitudes which separate radio generators from infra-red generators.
—*Proceedings of the I.R.E.* (U.S.A.), October, 1952, p. 1161.

TELEVISION

The principal difficulties in presenting television pictures to large audiences has been insufficient illumination of a large screen and lack of contrast and fine details. A description is given of the "intermediate film" system which is now regaining favour. In the registering apparatus the picture is reproduced on a CRT where it is photographed. The exposed film is driven continuously through the processing tanks and emerges processed in 60 seconds and projected.
—*Proceedings of the I.R.E.* (U.S.A.), October, 1952, p. 1177.

Noise limiters for television sound. The article deals with the shunt limiter and the compound limiter with notes on overall performance.
—*Wireless World* (Eng.), September, 1952, p. 339.

MISCELLANEOUS

With the advance of electronic equipment into the microwave region and the increased use of high frequencies in the medical field, studies have been inaugurated to ascertain their effects on living organisms. Findings of experiments on laboratory animals indicate that these waves heat internal organs dangerously upon long irradiation, but that apparently there are no biological effects other than those due to temperature changes.
—*Electrical Engineering* (U.S.A.), October, 1952, p. 879.

The degree of precision attained by modern frequency standards has rendered Greenwich Mean Time unsuitable as a basis for the assessment of performance. In the time service maintained by the Royal Greenwich Observatory, the errors arising from polar variation are removed. With the clocks now available estimates are being made of the amplitude and phase of annual fluctuation of the earth's rotation, and complications in an accurate time system are described.
—*Proceedings of the I.E.E.* (Eng.), Sept. 1952 (Pt. III), p. 320.

Synch. Signal Generator

(Continued from Page 21.)

frequency, a frequency divider, dividing by two is included, and this drives the pulse generators for both types of line-frequency pulse. Part two of this series embarks on a description of the detailed circuits contained in this portion of the block diagram.

(To be continued.)

REFERENCES

(1) *The Principles of Television Reception,* by A. W. Keen (Pitman).

(2) *Television Receiving Equipment,* by W. T. Cocking (Iliffe).

(3) *Television,* by F. Kerkhof and W. Werner (Philips Technical Library).

(4) *Principles of Television Engineering,* by D. G. Fink (McGraw-Hill).

High-Powered Amplifier

(Continued from Page 7.)

up could be fed directly to Input 3 of the pre-amplifier circuit, with a 1 meg. to 1 meg. load resistor connected across it. If a magnetic pick-up is to be used, and is a high quality unit which requires compensation for the recording characteristic to be introduced, a further valve will be needed. It can have a very simple circuit, and need not have a gain of more than about three times. If a lower level pick-up is used, the same circuit, with only slight modification, can be made to give a gain of up to 20 times, as well as compensation. If it is intended to play either 78 or L/P records, then simple switching can be arranged to select the correct response curve.

POWER SUPPLY

In next month's issue we will complete the story of this amplifier by discussing the problems to be encountered in designing a suitable power supply for the amplifier, and by giving a suitable power supply circuit, designed according to the principles discussed.

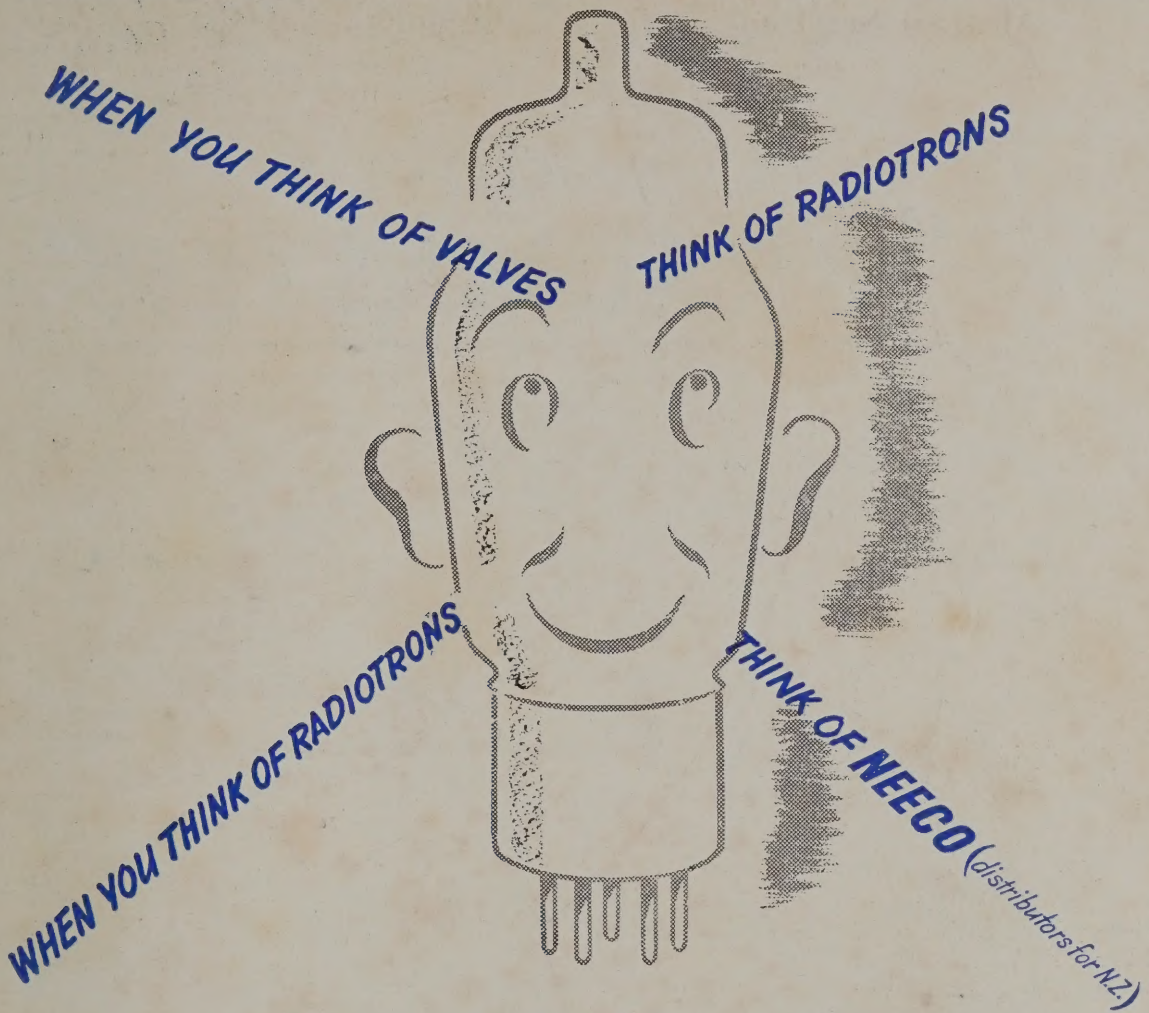
Electronic Switch

(Continued from Page 14.)

attenuation is needed for examining any waveform whose approximate voltage- peak-to-peak, is known. For example, if the waveform is 50 volts peak-to-peak, the peak voltage will be 25 volts, and an attenuator reducing the input to the valve to one twenty-fifth of the waveform's voltage will enable the amplifier not to be overloaded.

The output voltage is not very great, but even if it is connected directly to the Y-plate of the 'scope, it will give a larger picture than might be imagined. The peak-to-peak output voltage will be just over 15 volts, and this is enough to give a useful deflection on the C.R.T. If it is not enough then it will be necessary to follow the switch by a wide-band amplifier which can handle the switching square-wave without much distortion. A little droop on the square-wave response is more noticeable when the traces made by the switch are blank than when there are signal waveforms present, and some slight droop might be preferable to a picture that is too small. However, if there are two waveforms on the 'scope at once, it is not necessary for them both to be as large as is usually the case when only one is present, simply because each of them takes up some room on the face of the tube.

In our own laboratory, we have a wide-band amplifier which is used with the 'scope. (This was described in the March and April 1950 issues of *Radio and Electronics.*) This amplifier was found quite suitable for use following the switch circuit, and enables full-sized patterns to be obtained on the six-inch C.R. tube without too much trouble from droop effects. The amplifier actually has a much greater bandwidth than the amplifiers in the switch, having useful response up to 4½ mc/sec., but to be useful, the circuit used need not have as wide a response as this. We hope to publish at a later date, for those who may be interested, a simple wide-band amplifier which can be used with this electronic switch, and which will have response up to about 1 mc/sec. This would greatly expand the usefulness of any 'scope, particularly with the switch added, and the two could be built as one unit.



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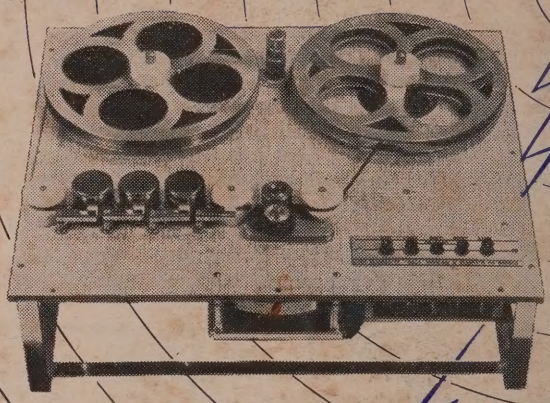

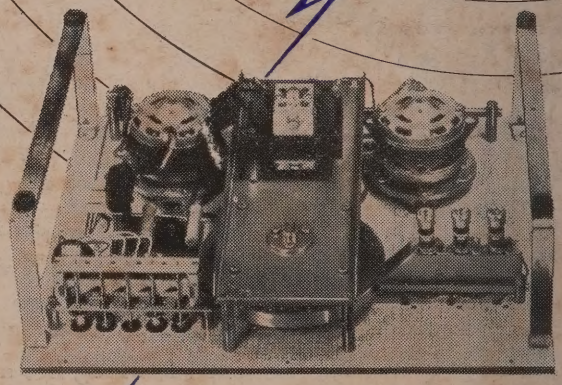

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Tape Speed 7½ in. per sec.—
60– 8,000 C.P.S. plus and minus 4 db.
50–10,000 C.P.S. plus and minus 7 db.
40–11,000 C.P.S. plus and minus 10 db.

Tape Speed 3¾ in. per sec. (speech only)—
60–5,000 C.P.S. plus and minus 5 db.
60–6,000 C.P.S. plus and minus 10 db.

Recommended circuits for pre-amplifier, compensation, and bias/erase sections of the electronic equipment are available with each deck if required.

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